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Titlepage and Contents enclosed

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# Recherches sur la Biologie du Rotifère *Eosphora najas* Ehrenberg

par

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Depuis un demi-siècle, un certain nombre de chercheurs se sont intéressés à la fécondité, à la durée de la vie et à quelques autres données biologiques des Rotifères. En 1946 et 1948 EDMONDSON a recensé les principaux résultats obtenus par les différents auteurs ayant travaillé sur ces questions.

Comme le constate cet auteur, il n'existe que peu de données complètes sur la reproductivité des Rotifères. De plus les expériences ont été souvent poursuivies dans des conditions quelque peu complexes et rarement bien définies; en particulier la température à laquelle elles sont conduites n'est pas toujours précisée; en ce qui concerne la nourriture, le plus fréquemment d'origine algale, aucun essai préliminaire en vue de déterminer la nourriture préférentielle de chaque espèce ne paraît avoir été tenté; or, ces facteurs influent généralement sur le taux de reproduction parthénogénétique. Enfin assez rares sont les auteurs ayant expérimenté sur de véritables élevages, au sens strict du terme (c'est à dire, maintien au laboratoire de souches obtenues à partir d'une seule femelle amictique, alimentée par une souche végétale, ou animale dans le cas d'un Rotifère carnivore).

Afin d'accroître nos connaissances sur la Biologie des Rotifères, j'ai pensé qu'il serait intéressant d'étudier une souche d'*Eosphora najas* EHRENBURG.

Le choix de cette espèce a été motivé par la facilité de l'élever dans des conditions parfaitement connues, et par ses caractères généraux, différents de ceux des espèces expérimentées jusqu'à présent; *Eosphora najas* est un Notommatide assez fréquemment récolté, à mastax tendant vers le type forcé (préhenseur), et par là carnivore.

Si l'étude expérimentale des Rotifères planctoniques phytophages présente beaucoup d'intérêt, celle des Rotifères carnivores en présente également, les seconds pouvant détruire complètement, à eux seuls, certaines populations des premiers ainsi que j'ai pu l'observer au moins dans le cas de petites collections d'eau naturelles.

#### A. — MATERIEL ET METHODE.

La femelle amictique d'*Eosphora najas*, à l'origine de la souche, a été récoltée en Mai dans une mare de ferme de Saint-Aubin (Seine-et-Oise). Le Zooplancton de cette mare était composé en majeure partie de *Brachionus calyciflorus* PALLAS dont les *Eosphora* semblaient se nourrir. Un élevage fut constitué au laboratoire selon les méthodes exposées dans un précédent travail; les *Eosphora* ont été alimentées de *Brachionus calyciflorus* provenant d'une souche que m'a aimablement fournie Monsieur DE BEAUCHAMP; cette dernière était elle-même alimentée de *Chlorella pyrenoidosa* CHICK.



Fig. 1 — Femelle amictique d'*E. najas* x 150.

Pour déterminer les constances de la souche d'*Eosphora najas*, j'ai opéré comme suit: quelques jeunes femelles sont prélevées de l'élevage, et chacune est isolée dans un verre de montre contenant quelques centimètres cubes du milieu d'élevage et une vingtaine de brachions; comme milieu d'élevage, j'ai utilisé une dilution au 1/3



du milieu de LEFEVRE pour cultures d'algues, sans extraits organiques ( $\text{NO}_3\text{K}$  100mg,  $(\text{NO}_3)_2\text{Ca}$  100 mg,  $\text{PO}_4\text{HK}_2$  40 mg,  $\text{SO}_4\text{Mg}$  30 mg); les verres de montre sont placés en chambre humide.

La nourriture et le milieu sont fréquemment renouvelés, afin d'éviter la pollution bactérienne que intervient rapidement en cellule.

Les observations sont faites, au minimum, toutes les heures. Dès la ponte (ou l'éclosion) l'oeuf (ou le jeune) est isolé et suivi à la loupe binoculaire. On note l'heure à laquelle la ponte (ou l'éclosion) est effectuée et l'heure de l'observation précédente. La moyenne de ces deux heures donne l'heure de la ponte (ou de l'éclosion) à 30 minutes près.

Les expériences ont été faites à la température du laboratoire, qui a été maintenue le plus possible entre 23° et 25°C.

## B. - OBSERVATIONS SUR L'ETHOLOGIE ALIMENTAIRE.

DE BEAUCHAMP, dans ses premiers essais d'élevage de Rotifères, avait réussi à nourrir cette espèce de *Lepadella patella* MÜLLER et avait constaté qu'elle était capable d'ingérer des proies de grande taille, telles que des *Euchlanis*.

Au laboratoire j'ai fourni comme nourriture aux *Eosphora*, 5 souches de Rotifères qu'elles ont fort bien accepté en général: *Brachionus calyciflorus* PALLAS, *Euchlanis dilatata* EHRENBERG, *Monostyla pyriformis* DADAY et deux Bdelloïdes: *Rotaria rotatoria* PALLAS, *Philodina roseola* EHRENBERG; ces 5 espèces étaient entretenues sur du milieu d'élevage régulièrement enrichi en chlorelles.

Selon la proie à laquelle elles ont affaire, le comportement des *Eosphora* diffère.

a) Les Bdelloïdes sont généralement attrapés par leur extrémité antérieure et toujours avalés en totalité; il en est d'ailleurs de même des petites espèces de Ploïmes, telles que les *Monostyla* et *Lepadella*; après digestion de la proie, ses parties dures (mastax, et s'il y a lieu, lorica) sont rejetées par le cloaque du Notommatide; il n'est pas rare de les voir expulser en même temps qu'un oeuf, du fait de la forte contraction musculaire survenant à ce moment.

b) Les grandes formes de Ploïmes possédant une lorica (*Brachionus* et *Euchlanis*) – hormis les jeunes, de petite taille – ne peuvent être que difficilement avalées en entier; en règle générale, les prédateurs les attaquent de face et arrachent avec leur mastax tout ce qu'ils peuvent extraire de la lorica de leur proie: couronne ciliaire, une partie du tube digestif (y compris le mastax parfois) et de l'appareil génital.

Par ce procédé, il est évident que la chair de la proie n'est jamais

complètement extraite et une partie plus ou moins importante est abandonnée avec la lorica, quand l'*Eosphora* ne peut plus s'en emparer.

Lorsqu'une *Eosphora* s'attaque à un brachion, il peut arriver qu'elle s'empale sur une des épines antérieures du brachion, et, ne pouvant s'en détacher, en meurt.

Le nombre de ces proies vidées par une seule *Eosphora* varie entre 15 et 20 par jour, à la température de 24° environ.

Quelques tentatives faites pour alimenter *Eosphora najas* de Paramécies se sont soldées par un échec total; de plus, bien qu'elles puissent ingérer des Algues telles que *Pandorina morum* BORY ou *Haematococcus pluvialis* FLOTOW EM. WILLE, les *Eosphora* sont incapables de subsister avec une nourriture uniquement algale.

Dans leur mare d'origine les *Eosphora najas* proliféraient surtout aux dépens des nombreux *Brachionus calyciflorus* qu'elles éliminèrent en peu de temps. Cette espèce est donc exclusivement carnivore et doit se nourrir essentiellement d'autres formes de Rotifères, ainsi qu'en témoignent les observations faites au laboratoire et dans la nature; en l'absence de toute nourriture, il n'est pas rare de voir les *Eosphora* s'entre-dévorer.

### C. - ETUDE DES FEMELLES AMICTIQUES.

A l'intérieur du corps d'une femelle amictique, il est aisé de distinguer un ovocyte mûr, prêt à être expulsé: de couleur plus soutenue que les tissus avoisinants, il est entouré d'une membrane qui lui confère déjà la forme ovoïde typique, qui est celle de l'oeuf immédiat d'*Eosphora najas*.

L'expulsion se fait par le cloaque, au passage duquel l'oeuf subit un rétrécissement. Chaque oeuf est fixé au substrat probablement par gélification de son enveloppe externe.

Les dimensions d'un oeuf immédiat sont de l'ordre de 140—150  $\mu$  de long, et 120—130  $\mu$  de large.

A l'intérieur de la membrane, les cils commencent à battre très tôt et quelques heures avant l'éclosion, on peut observer les mouvements du jeune embryon et de son mastax.

Le jeune Rotifère, une fois complètement formé, par ses contorsions et la pression qu'il exerce sur la paroi de l'oeuf, fend celle-ci selon une ligne de moindre résistance et sort.

Je me suis attaché à déterminer, à la température moyenne de 24°, le temps d'éclosion des jeunes, le temps de ponte du premier oeuf, le rythme de ponte, le temps de fonctionnement oogénétique, la durée de la vie et le nombre d'oeufs pondus par une femelle amictique.



Les observations ont porté sur un minimum de 15 individus.

### 1°) Temps d'éclosion de la jeune femelle.

La période de temps s'écoulant entre la ponte de l'oeuf et l'éclosion du jeune s'est établie comme suit:

- 1 jeune femelle est éclos en 23, 30 h.
- 3 jeunes femelles sont écloses en 24, 00 h.
- 2 jeunes femelles sont écloses en 24, 30 h.
- 4 jeunes femelles sont écloses en 25, 00 h.
- 3 jeunes femelles sont écloses en 25, 30 h.
- 2 jeunes femelles sont écloses en 26, 00 h.

En moyenne, la durée d'éclosion des jeunes femelles varie entre 24 et 26 heures.

### 2°) Temps de ponte du premier oeuf.

C'est le laps de temps séparant l'éclosion de la jeune femelle amictique de l'expulsion de son premier oeuf.

Les résultats observés sur 15 individus se sont répartis ainsi:

- 1 femelle a pondu son premier oeuf en 26, 30 h.
- 3 femelles ont pondu leur premier oeuf en 27, 00 h.
- 4 femelles ont pondu leur premier oeuf en 27, 30 h.
- 2 femelles ont pondu leur premier oeuf en 28, 00 h.
- 3 femelles ont pondu leur premier oeuf en 28, 30 h.
- 2 femelles ont pondu leur premier oeuf en 29, 00 h.

En moyenne, la ponte du premier oeuf intervient entre 27 et 29 heures après la naissance de la jeune femelle.

### 3°) Rythme de ponte.

Quinze femelles ont été suivies depuis leur éclosion jusqu'à leur mort; au cours d'observations faites toutes les 24 heures, au minimum, j'ai relevé le nombre d'oeufs pondus par jour, ainsi que la date d'arrêt de la ponte et celle de la mort de la femelle; ces dernières ne sont connues qu'à 12 heures près, du fait que l'arrêt du fonctionnement oogenétique et la mort de l'animal intervenaient parfois la nuit.

Les résultats obtenus sont consignés dans le tableau de la page suivante.

En considérant l'ensemble de ces exemples, on peut en déduire que:  
- Le nombre d'oeufs pondus par jour varie de 4 à 5 en moyenne pendant les 5 premiers jours de la vie de chaque femelle; il diminue souvent pendant les derniers jours.

N.B. Le nombre d'oeufs pondus au cours de la 2ème journée est parfois légèrement inférieur à celui de la 3ème journée; en fait, l'expulsion du 1er oeuf intervenant 27 à 29 heures après l'éclosion, le rythme de ponte de la 2ème journée de la vie de l'animal est sensiblement égal ou même, comme c'est le cas général, quelque peu supérieur à celui de la 3ème journée.

# NOMBRE D'OEUFS PONDUS PAR JOUR

♀ N°	1er jour	2ème jour	3ème jour	4ème jour	5ème jour	6ème jour	7ème jour	8ème jour	9ème jour	10ème jour	11è jour
I	0	6	6	5	2	x					
II	0	4	4	3	4	4x					
III	0	4	4	5	4	3	0	0	x		
IV	0	4	5	5	4	3	x				
V	0	6	4	4	5	3	0	x			
VI	0	5	4	5	5	3	0	0	x		
VII	0	4	4	3	4	4	3	0	x		
VIII	0	5	4	4	3	4	2	x			
IX	0	5	5	4	4	3	2	0	x		
X	0	4	5	4	4	3	3x				
XI	0	6	6	5	5	3	0	x			
XII	0	5	5	5	5	4	1	0	0	x	
XIII	0	4	5	5	4	3	3	1x			
XIV	0	4	4	5	5	3	3	2	0	x	
XV	0	4	5	5	5	4	3	1	0	0	

N.B. - Le signe x indique la mort de l'animal.

- Le numéro d'ordre donné à chaque femelle est purement conventionnel.

- Certaines femelles (n° XI du tableau) ont un rythme de ponte plus rapide qui se retrouve au moins dans leurs premiers descendants (la femelle n° I du tableau est issue du septième oeuf de la femelle n° XI).

Toutes ces données correspondent à la généralité des cas; mais, au cours des observations, quelques irrégularités ont été relevées:

- Exeptionnellement, l'éclosion du jeune peut être retardée et même avorter, le jeune ne parvenant pas à se libérer de sa coquille.

- Il arrive, quoique rarement, que la ponte du premier oeuf soit



différée; dans ce cas, le plus souvent, le rythme de ponte des oeufs suivants est accéléré, de sorte qu'une irrégularité compensant l'autre, le nombre d'oeufs pondus par jour reste sensiblement identique au cas général.

– De même, l'intervalle de temps séparant chaque ponte n'est pas toujours régulier pour une dizaine de cas où il a été compris entre 4 et 6 heures, il s'en est trouvé deux où il a été de 3 heures, et deux autres où il a nettement dépassé 6 heures.

Ceci est probablement dû à l'inégalité de la quantité nourriture absorbée par une femelle au cours d'une journée, du fait même de la façon dont elle se nourrit; sur une période de temps de 24 heures, cette inégalité peut s'effacer au point de ne pas influencer sur le rythme de ponte quotidien.

**4°) Temps de fonctionnement oogénétique et durée de la vie.**

Le temps de fonctionnement oogénétique représente l'intervalle de temps s'écoulant entre la naissance de l'animal et la ponte de son dernier oeuf. En y ajoutant la durée de la période de vieillesse, c'est-à-dire le temps compris entre l'arrêt de la ponte et la mort de l'animal, on obtient la durée totale de la vie. Les résultats notés dans le précédent tableau peuvent être exprimés de la façon suivante:

Nombre d'oeufs pondus par animal	Temps de fonctionnement oogénétique (en jours)	Durée de la vie (en jours)
19	5	6
19	6	6
20	6	9
21	6	7
22	6	8
22	6	9
22	7	9
22	7	8
23	7	9
23	7	7
25	6	8
25	7	10
25	8	8
26	8	10
27	8	11

La période de vieillesse variant de quelques heures à 3 jours, le nombre d'oeufs pondus est en rapport plus étroit avec le temps de fonctionnement oogénétique qu'avec la durée de la vie. La quantité totale des oeufs pondus pendant la vie d'une femelle amictique est d'autant plus élevé que le temps de fonctionnement oogénétique est plus long.

Pendant la période de sénilité l'animal ne s'alimente presque plus, prend une teinte brune de plus en plus uniforme; la mobilité diminue, puis le mastax cesse tout mouvement; seuls quelques cils de la couronne ciliaire continuent à tourner, l'animal étant complètement immobile, et finissent également par s'arrêter.

L'animal meurt en extension complète; il a vécu en moyenne de 8 à 10 jours.

#### 5°) Nombre d'oeufs pondus pendant la totalité de la vie d'une *Eosphora najas* et taux de reproduction.

Aux résultats précédents viennent s'ajouter ceux de dix autres expériences poursuivies uniquement dans le but de déterminer le taux de reproduction parthénogénétique.

Les 25 chiffres obtenus se répartissent comme suit;

3 *Eosphora* ont pondu de 13 à 15 oeufs.

6 *Eosphora* ont pondu de 16 à 20 oeufs.

12 *Eosphora* ont pondu de 21 à 25 oeufs.

4 *Eosphora* ont pondu de 26 à 28 oeufs.

En moyenne, le nombre d'oeufs pondus se situe aux alentours de 23 oeufs par individu.

La durée de la vie étant en moyenne de 9 jours, le taux de reproduction, quotient de ces deux chiffres, est de 250 % par jour, dans les conditions de l'expérience.

#### D. - INFLUENCE DES FACTEURS EXTERNES SUR CES CONSTANTES.

La qualité de la nourriture ne semble avoir qu'une influence assez faible: quelques expériences où les brachions ont été remplacés par des *Euchlanis dilatata*, ont donné des résultats identiques aux précédents.

Les *Rotaria rotatoria* m'ont paru légèrement moins favorables à l'élevage des *Eosphora* que les Ploïmes cités ci-dessus. Les oeufs qui ne sont pas parvenus jusqu'au stade de l'éclosion ont été plus nombreux. Le temps d'éclosion des jeunes femelles amictiques a été de 25 heures en moyenne, mais pour une température légèrement plus élevée (25° de moyenne).



La température a une influence nettement plus considérable et des expériences sur ce point doivent être faites ultérieurement.

## E. — LES FEMELLES MICTIQUES

Dans les élevages nourris de *Brachionus calyciflorus* ou d'*Euchlanis dilatata*, les *Eosphora* se sont multipliées uniquement parthénogénétiquement; la présence d'aucune femelle mictique n'a été observée.

Seules les *Eosphora* alimentées de *Rotaria rotatoria* ont montré des femelles pondueuses d'oeufs mâles dans leur descendance. Ce fait ne semble pas dû au changement de nourriture, mais serait inhérent à l'alimentation par les *Rotaria*: la présence de quelques femelles mictiques s'observe dans tout élevage nourri, même continuellement, de *Rotaria rotatoria*.

Du fait de la différence de nourriture, les mesures portant sur les temps d'éclosion des mâles ne sont pas absolument comparables aux résultats énoncés ci-dessus et concernant les oeufs immédiats, bien que les différences soient minimales. Néanmoins, afin de posséder une meilleure base de comparaison, quelques femelles amictiques ont été suivies parallèlement aux mictiques et dans les mêmes conditions.

Malheureusement, en raison de leur petit nombre et de l'impossibilité de les faire apparaître à un moment précis, la naissance des femelles mictiques n'a pu être contrôlée rigoureusement; de plus, parmi les oeufs mâles qui ont pu être suivis, peu sont arrivés au terme de l'éclosion.

Aussi, les résultats consignés ci-dessous devront être considérés comme de simples observations et non comme des constantes bien établies.

Les expériences ont été faites à la température moyenne de 25°C.

### 1°) Temps d'éclosion du jeune mâle.

C'est la période de temps qui sépare la ponte d'un oeuf mâle de l'éclosion du jeune.

Cinq oeufs mâles isolés dès leur ponte sont éclos dans des temps compris entre 24 et 26 heures. A l'intérieur de cinq autres oeufs, les jeunes mâles bien vivants ont été observés parfaitement constitués au bout d'un temps identique, mais ils n'ont pas réussi à éclore. Il m'a semblé que l'éclosion était plus difficile pour les mâles que pour les femelles.

Dans les mêmes conditions 2 jeunes femelles amictiques sont écloses en 25 heures environ. Le temps d'éclosion d'un mâle paraît donc à peu près identique à celui d'une femelle.

Les oeufs mâles sont plus petits que les oeufs femelles: leurs dimensions sont de l'ordre de 120—130  $\mu$  de long et 100—110  $\mu$  de large.

## 2°) Le mâle et la fécondation.

Le mâle a été fort bien décrit et figuré par DE BEAUCHAMP en 1905; cependant ce dernier n'ayant pu étudier qu'un petit nombre d'exemplaires a laissé subsister un doute sur le nombre (6 ou 8) de flammes vibratiles que possède un mâle d'*Eosphora najas*. Un examen sur le vivant montre qu'il existe 8 flammes (4 de chaque côté) comme chez la femelle.

La durée de la vie du mâle n'excède que peu 24 heures.

Des femelles mictiques isolées et laissées en présence des mâles issus de leurs propres oeufs n'ont pas été fécondées par leurs fils et ont continué à pondre des oeufs mâles.

Ceci laisserait à penser qu'il ne peut y avoir de fécondation des femelles par leurs propres fils, au moins dans les conditions expérimentales.

D'autre part, des femelles ayant déjà pondu quelques oeufs mâles ont été isolées et mises en présence de mâles issus d'autres femelles; la fécondation n'a pas eu lieu, non plus, dans ces conditions et la ponte d'oeufs mâles s'est poursuivie. Il serait donc possible que la fécondation par un mâle ne puisse intervenir que sur les jeunes femelles mictiques immatures; toutefois, cette hypothèse n'a pas pu être vérifiée.

En définitive, la présence d'oeufs durables n'a été relevée que dans les élevages où coexistaient plusieurs femelles mictiques.

## 3°) Les femelles mictiques non fécondées (femelles isolées dès leur naissance).

— Le nombre d'oeufs mâles pondus par une femelle mictique non fécondée est au moins égal à celui des oeufs femelles pondus par une femelle amictique (entre 20 et 30 oeufs par individu).

— Le rythme de ponte s'est établi ainsi: alors que 2 femelles amictiques pondaient 5 et 4 oeufs en 24 heures, 3 femelles mictiques ont pondu 6, 6 et 5 oeufs dans le même temps. Corrélativement, l'intervalle de temps séparant chaque ponte a été de 4,30 et 5,30 heures, pour les femelles amictiques et de 3,30 et 4,00 heures pour les femelles mictiques.

Le rythme de ponte des oeufs mâles serait ainsi un peu plus rapide que celui des oeufs femelles immédiats.

— La durée de la vie est, au moins, du même ordre de grandeur: 8 à 10 jours, quelquefois plus.



#### 4°) Les femelles mictiques fécondées.

— Le nombre d'oeufs de durée pondus par une femelle mictique fécondée dès les premiers jours de sa vie est très faible: isolées en cellule après fécondation et convenablement nourries cinq femelles mictiques n'ont pondu que 1 à 3 oeufs durables, (en moyenne, 2 oeufs par animal); les derniers oeufs étaient parfois manifestement destinés à avorter.

— L'intervalle approximatif compris entre deux pontes d'oeufs de durée d'une des femelles a été de 53 heures (à 12 heures près); pour deux autres femelles, il s'est situé entre 2 et 3 jours.

— La durée de la vie, bien qu'il subsiste une assez grande incertitude sur la date de naissance de l'animal, m'a semblé du même ordre de grandeur que celle des femelles non fécondées.

— La période de sénilité a varié de 2 à 6 jours; elle paraît généralement plus longue chez les femelles mictiques que chez les femelles amictiques.

Le temps de ponte du premier oeuf mâle ou du premier oeuf durable (dans le cas où la femelle fécondée avant sa maturité sexuelle pond directement des oeufs de durée) n'a malheureusement pas pu être déterminé.

#### 5°) L'oeuf durable.

Il a été décrit et figuré par PENARD en 1914; mais sa description ne correspond pas exactement à celle des oeufs durables que j'ai observé dans mes élevages.

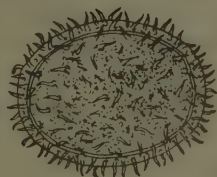


Fig. 2 — Oeuf durable d'*E. najas* x 150.

Ces derniers sont généralement plus gros que l'oeuf de durée vu par PENARD; leurs dimensions sont en moyenne de 170  $\mu$  de long et 130  $\mu$  de large. Les poils garnissant la surface externe de la coque ont une longueur variable: ils peuvent être réduits à l'état de petits piquants ou être allongés et plus flexibles.

Les résultats obtenus avec les femelles mictiques sont évidemment incomplets; mais l'apparition de ces femelles étant aléatoire, je n'ai pu apporter plus de précision à leur sujet.

L'ensemble de ces observations fournit un aperçu sur la biologie d'*Eosphora najas* EHRENBURG; ces quelques données font aisément concevoir qu'un tel animal, armé d'un mastax puissant lui permettant de s'attaquer avec succès à des espèces très différentes de Rotifères et doué d'une assez grande rapidité de multiplication, soit un carnassier de premier ordre, détruisant les populations rotifériennes benthiques ou planctoniques jusqu'à ce que, faute de nourriture, il disparaisse à son tour.

## RESUME

1°) En premier lieu, l'auteur rappelle ou complète quelques notions sur l'éthologie alimentaire d'*Eosphora najas*.

2°) Une étude des femelles amictiques alimentées de *Brachionus calyciflorus* à la température moyenne de 24° C. conduit aux résultats suivants:

- Dimensions des oeufs immédiats: 140—150  $\mu$  de long 120—130  $\mu$  de large.

- Temps d'éclosion de la jeune femelle compris entre 24 et 26 heures.

- Temps de ponte du premier oeuf compris entre 27 et 29 heures après la naissance de la jeune femelle.

- Rythme de ponte: 4 à 5 oeufs par jour en période de reproduction active. Différences entre les lignées (quelques-unes ont un rythme de ponte plus rapide).

- Temps de fonctionnement oogénétique: 6 à 8 jours. Plus il est long, plus le nombre d'oeufs pondus est élevé.

- Durée de la vie: 8 à 10 jours en moyenne.

- Nombre d'oeufs pondus pendant la vie de la femelle: 23 en moyenne.

3°) Influence des facteurs externes:

La nourriture ne semble avoir que peu d'effet à l'inverse de la température qui a une grande influence.

4°) Quelques observations ont été faites sur les femelles mictiques à la température moyenne de 25°C.:

- Apparition de femelles mictiques dans les élevages d'*Eosphora najas* nourries de *Rotaria rotatoria*.

- Temps d'éclosion du mâle: 25 heures environ.

- Durée de la vie des mâles: 1 journée approximativement.

- Rythme de ponte des oeufs mâles un peu plus rapide que celui des femelles.

- Nombre d'oeufs mâles pondus par une femelle non fécondée: de 20 à 30.



- Dimensions des oeufs mâles: 120—130  $\mu$  de long et 100—110  $\mu$  de large.
- Rythme de ponte des oeufs de durée: lent, environ 2 jours d'intervalle entre 2 pontes successives.
- Nombre d'oeufs pondus par une femelle fécondée peu élevé: 2 à 3.
- Dimensions des oeufs durables: 170  $\mu$  de long et 130  $\mu$  de large.

## SUMMARY

1°) At first, the author completes, or reminds of some notions on the feeding habits of the Rotatoria, *Eosphora najas* EHRENBURG.

2°) A study of the amictic females, feeding on *Brachionus calyciflorus* PALLAS, at the mean temperature of 24°C., leads to the following results:

- Size of immediate eggs: 140—150  $\mu$  x 120—130  $\mu$ .
- Time of hatching of the young female about 24 to 26 hours.
- Laying of the first egg: 27 to 29 hours after the birth of the young female.
- Rhythm of eggs laying: 4 to 5 eggs per day, in period of active reproduction. There are differences between the offsprings: some have a faster rhythm of eggs laying.
- Time of oogenetic working: 6 to 8 days. The longer this time, the higher is the number of eggs laid.
- Length of life: 8 to 10 days.
- Mean number of eggs laid during the female's life: about 23.

3°) Influence of exteriors factors:

- The food seems to have few effect, contrary to the temperature which has a great influence.

4°) Some observations have been made on the mictic females at the temperature of 25°C.

- Apparition of the mictic females in *Eosphora's* breeding feeding on *Rotaria rotatoria*.

- Time of hatching of the young male: about 25 hours.
- Length of male's life: about a day.
- Rhythm of laying of the male eggs, a little faster than that of the female eggs.
- Mean number of male eggs laid by an unfecondated female 20 to 30.
- Size of male eggs: 120—130  $\mu$  x 100—110  $\mu$ .
- Rhythm of laying of resting eggs: slow, about 2 days of interval between two egg's laying.
- Number of resting eggs laid by a fecundated female, feeble (2 to 3).
- Size of resting eggs: 170  $\mu$  x 130  $\mu$ .

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# The Larvae of Corixidae and an attempt to key the last larval instar of the Dutch species (Hem., Heteroptera)

by

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1. Introduction.
2. List of Dutch species.
3. Review of literature on the last larval instar.
4. Comparative morphology of the last larval instar.
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  - b. Head.
  - c. Thorax.
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7. The development of distinguishing characters and the possibilities of identifying the younger instars.
8. Discussion of the characters in relation to corixid classification.
9. Acknowledgements.
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## 1. INTRODUCTION

The *Corixidae* always have formed a rewarding object for morphological, functional-morphological, sense-physiological and in particular ecological studies. There exists, then, a voluminous literature about them (see for example references in WEBER (1933), WESENBERG-LUND (1943), POISSON (1951), FERNANDO (1959) and SOUTH-

WOOD & LESTON (1959)). For the ecologist, who is confronted with the intriguing phenomenon of the mass flights of corixids and the quickly changing populations in new water-habitats, it is important to know how strong the association of the species is with the conditions on the spot. Is the presence of the species fortuitous, very temporary or constant during at least the period of one generation? Which species come to lay eggs, how far does the larval development succeed, what are the ecological demands of the larvae, etc.?

To begin a study with this intention, one must first be able to identify the larvae down to the species. The purpose of the present paper is to show how far this is possible. The whole study is based on material stored in 80 percent alcohol and investigated in a mixture of alcohol, glycerine, and water.

## 2. LIST OF DUTCH SPECIES

Students of corixid taxonomy have no complaints to make of scarcity of good keys. Within six years five identification works have appeared, namely HÖREGOTT & JORDAN (1954, Germany), STICHEL (1955, Europe), MACAN (1956, Britain), POISSON (1957, France) and SOUTHWOOD & LESTON (1959, Britain). All Dutch species are treated in STICHEL and POISSON; *S. hellensi* is lacking in the British fauna; the key of HÖREGOTT & JORDAN is intended in the first place for the identification of the females.

Data on the *Corixidae* occurring in the Netherlands (called in Dutch: „duikerwantsen”) are summarized in RECLAIRE's Naamlijst en Vervolgen (1932, 1934, 1936, 1940, 1943, 1948 and 1950). The nomenclature in RECLAIRE's check-list (1948, page 64) is out of date now, and *S. dorsalis* must be added to the faunal list.

For reasons given on page 354, we preferred the classification used in STICHEL (1955), transferring *concinna* however to *Sigara*. In reality it follows the genera conceptions of HUNGERFORD (1948) without the division of *Sigara* into subgenera. Species groups are indicated by spaces in the list below. Species whose occurrence in the Netherlands still has to be confirmed are indicated by a question-mark. The larvae of the species marked with an asterisk could not be included in our study because of lack of material. However, the possibilities for identification of the larvae V of those species are discussed in the key (page 342-348).

SUBFAM. **Micronectinae** J.

Genus *MICRONECTA*

*poweri* (DGL. & SC.) \*?

*minutissima* (L.) \*

*meridionalis* (C.)

SUBFAM. **Cymatiinae** HF.

Genus *CYMATIA*

*bonsdorffi* (C. SB.)

*coleoptrata coleoptrata* (F.)

SUBFAM. **Corixinae** END.

Tribe **GLAENOCORISINI** HF.

Genus *GLAENOCORISA*

*propinqua* (FB.)

Tribe **CORIXINI** WLT.

Genus *CORIXA*

*affinis affinis* LCH. \*

*panzeri* FB. \*

*punctata* ILL.

*dentipes* (TH.) \*

Genus *HESPEROCORIXA*

*moesta* (FB.) \*

*castanea* (TH.)

*linnei* (FB.)

*sahlbergi* (FB.)

Genus *ARCTOCORISA*

*germari* (FB.)

Genus *SIGARA*

Subgenus *Subsigara*

*fossarum* (LCH.)

*scotti* (FB.)

*falleni* (FB.)

*distincta* (FB.)



Subgenus *Sigara*

*striata* (L.)

*dorsalis* (LCH.) \*

*semistriata* (FB.)

*venusta* (DGL. & Sc.) \*

*limitata* (FB.) \*

*lateralis* (LCH.) (= *hieroglyphica* (DF.))

*nigrolineata* (FB.)

*concinna* (FB.)

*stagnalis* (LCH.) (= *lugubris* (FB.))

*selecta* (FB.) \*

*hellensi* (C. SB.)

Genus *CALLICORIXA*

*praeusta* (FB.)

*wollastoni* (DGL. & Sc.) \*?

### 3. REVIEW OF LITERATURE ON THE LAST LARVAL INSTAR

Very fragmentary descriptions or figures of the last larval instar of *Corixidae* are given in BUTLER (1923, 9 species), HUNGERFORD (1948, 1 species), LINDBERG (1935, 1 species), PÉNEAU (1922, 1 species) and POISSON (1957, 2 species). It is striking, however, that none of them appear to contain characters of specific value. Though the species-name has been mentioned particularly, from most of the descriptions or figures one can diagnose only: „a corixine larva”; at the best the diagnosis makes identification to a species-group possible.

More extensive studies on the larvae of mostly a single species have been made by HAGEMANN (1910), ABBOTT (1912), HUNGERFORD (1919), CAROLI (1924), GRIFFITH (1945), SUTTON (1947), BOBB (1953) and WRÓBLEWSKI (1958). We shall analyse these studies here in more detail.

HAGEMANN (1910, p. 380—385) mentions all instars of *Corixa punctata* ILL. As his object merely was to follow the course of the respiratory mechanism, neither from his text, nor from his figures can we elicit morphological data which are specific for *C. punctata*, the genus *Corixa* or the subfamily *Corixinae*.

ABBOTT (1912) dwells at length on the morphology of the larvae of

*Ramphocorixa balanodis*, but the very characters of specific value are described incompletely.

HUNGERFORD (1919, p. 215—233) gives detailed descriptions of all instars of three American species, of which two species are depicted. Except for the exact reproduction of the color pattern, the remaining essential characters of specific value are lacking.

CAROLI (1925) describes the larvae of *Corixa monticellii*. This paper excels by the accuracy of the descriptions and figures; it gives nearly all informations on the larvae necessary for recognizing the species. STICHEL (1955, p. 58) places this species in the genus *Hesperocorixa*. However, on account of the hair-covering on the mesonotum of the larva V, as illustrated by CAROLI, the generic position of *monticellii* remains uncertain.

GRIFFITH (1945, p. 282—284) in his description of the larvae of the American *Ramphocorixa acuminata* (UHLER) neither mentions nor illustrates the specific characters. He states: „it is practicable to determine the common species of nymphs in the field, once they have been linked with the adults”. He restricts himself to tracing generic characters in the larvae and he selects for that purpose only one species out of each of the genera: *Ramphocorixa*, *Arctocorisa*, *Trichocorixa* and *Corisella*. His *Arctocorisa alternata* belongs however to *Sigara* (*Vermicorixa*) (cf. HUNGERFORD, 1948), the only genus that is present also in our fauna. GRIFFITH states: „Three characters, at least, are usable in separating the genera of corixid nymphs: size, color pattern, and appearance of the dorsal glandular patches on the abdomen”. It is self-evident that it is senseless to consider „size” as a genus-character, when we merely think of the differences in size in species of the genera *Cymatia* and *Corixa*. The colour pattern too is a priori very dubious as a character for separating genera. GRIFFITH does use, however, one feature which appears to be of major importance as a group-character, as we shall show farther on, namely the extent and the texture of the thick hair-covering upon the pterothorax.

SUTTON (1947) spends ten pages on the external morphology of the larvae of *Corixa panzeri* FB, but does not give us the data which would make it possible for us to include *panzeri* in our key to the last larval instar.

BOBB (1953) describes and figures all instars of the American *Hesperocorixa interrupta* (SAY). With our knowledge, dealt with in the present paper, one can conclude from BOBB's paper only that his larvae belong to a member of the genus *Corixa* or *Hesperocorixa*.

WRÓBLEWSKI (1958, p. 265) figures in detail the bodies of all larval instars of *Micronecta meridionalis* (COSTA). He makes some comparative remarks on the larvae of *M. minutissima* (L.), *griseola* HORV.

and *poweri* (DGL. & Sc.), describing differences in shade and shape of the dark pattern and in the relative size of the eyes. The extremities of the larvae of *M. meridionalis* are not figured by WRÓBLEWSKI, but, as he has shown in a very exact way for the imagines, reliable differences in structures of the legs may hardly be expected in the larvae.

POISSON (1957, p. 27) depicts the last instar of *M. poweri*, but inaccurately and with an entirely wrong view of the thorax.

#### 4. COMPARATIVE MORPHOLOGY OF THE LAST LARVAL INSTAR

The last, normally fifth, instar is always identifiable as such, as the wingpads extend to the anterior border or to the middle of the third abdominal segment.

##### *a. Body-measurements.*

The total length of the larvae is dependent on the position of the head and pronotum. Both are disc-shaped and have ventrally only a small point of attachment. This means that the head and the pronotum, dorsally loose from the pterothorax, can be moved far to the front to retain a supply of air. The distance between head and pterothorax of preserved specimens consequently appears to be very

TABLE I.

*Measurements of larvae V in mm.*

species	no. specimens measured	length LA	total width B	ratio LA/B	ratio LA/ medial length of pterothorax	wid h
<i>M. meridionalis</i>	4	2.1-2.2-2.25	1.2-1.25-1.3	1.8	3.7	0.
<i>C. bonsdorffi</i>	10	3.7-3.9-4.1	1.8-1.9 -2.1	1.9-2.1	4.2-4.6	1.7
<i>C. coleoptrata</i>	8	2.4-2.6-2.8	1.3-1.4 -1.5	1.9-2.0	3.6-4.3	1.2
<i>G. propinqua</i>	7	5.3-5.5-5.7	2.1-2.3 -2.6	2.2-2.5	3.7-4.2	2.1
<i>C. punctata</i>	8	8.4-8.6-8.9	4.2-4.3 -4.6	1.8-2.1	3.9-4.0	3.56
<i>H. castanea</i>	10	3.2-3.4-3.6	1.5-1.7 -1.9	1.9-2.2	4.2-4.6	1.55
<i>H. sahlbergi</i>	10	5.0-5.5-5.7	2.6-2.7 -2.9	1.8-2.0	4.3-4.5	2.20
<i>A. germari</i>	7	4.6-5.0-5.5	2.0-2.2 -2.5	1.9-2.3	4.2-4.5	1.90
<i>S. striata</i>	6	4.7-5.0-5.2	2.1-2.3 -2.5	2.1-2.2	4.3-4.5	1.80
<i>S. semistriata</i>	5	3.7-3.8-3.9	1.5-1.6 -1.7	2.3-2.4	3.4-3.8	1.50
<i>S. nigrolineata</i>	7	3.5-3.6-3.9	1.5-1.6 -1.7	2.0-2.4	3.9-4.2	1.50
<i>S. stagnalis</i>	10	3.9-4.2-4.4	2.0-2.1 -2.2	1.9-2.2	3.5-3.9	1.75
<i>C. praeusta</i>	10	4.5-4.8-5.0	1.9-2.1 -2.3	2.0-2.5	3.9-4.2	1.90



variable. As a linear measure we therefore have chosen the distance from the anterior border of the mesothorax to the apex of the abdomen, henceforth indicated as: Length LA.

Width B is the greatest width of the abdomen. As contrasted with the very extensible abdomina of the *Geocorisae*-larvae, those in the *Hydrocorisae* are tolerably constant. In table I are listed some body-measurements and ratios of one or some representatives of all genera occurring in the temperate zone of Europe. The ratios do not show reliable specific or even generic differences. The two species of *Cymatia* are distinguished from the rest by a relatively broader head.

#### b. Head

The adult character: rostrum without or with transverse furrows, also applies for the older larvae and distinguishes the *Cymatiinae* from the two other subfamilies. The eyes and frons of *Cymatia* and *Glaenocorisa* are protuberant, the frontal part is in lateral view slightly concave in both sexes and densely haired. In the remaining *Corixinae* the shape of the head and its frontal hairing is not or hardly discriminatory; the differences cannot be rendered in an exact way for use in a key. A conspicuous field-character is the black colour of the eyes in *Glaenocorisa*, whereas in the rest of the species it is mostly reddish. In alcohol this colour difference disappears in course of time.

#### c. Thorax

The pronotum, so important in the systematics of the adults, is of no taxonomic value in the larvae. It is an unobtrusive, finely and regularly haired, thin sheet, which is directed obliquely downwards, and hidden between mesothorax and the excavated back-side of the head. The dorsum of the pterothorax, however, is of high importance. Exclusive of *Micronecta*, the mesothorax has along the lateral sides and on the anterior border a covering of fine, short erect hairs. The dorsal side is covered with a thick wavy brownish to brown-blackish depressed hair-covering, extending along the innerside of the wing-pads to their apices (fig. 1—9). The extension of this hair-covering and the differentiation of the hairs in the middle of the mesonotum give an excellent and easily visible character to split the larvae into genera or groups of genera.

The following categories are recognizable:

Group I. Genus *Micronecta* (fig. 10).

Pterothorax dorsally entirely bare.

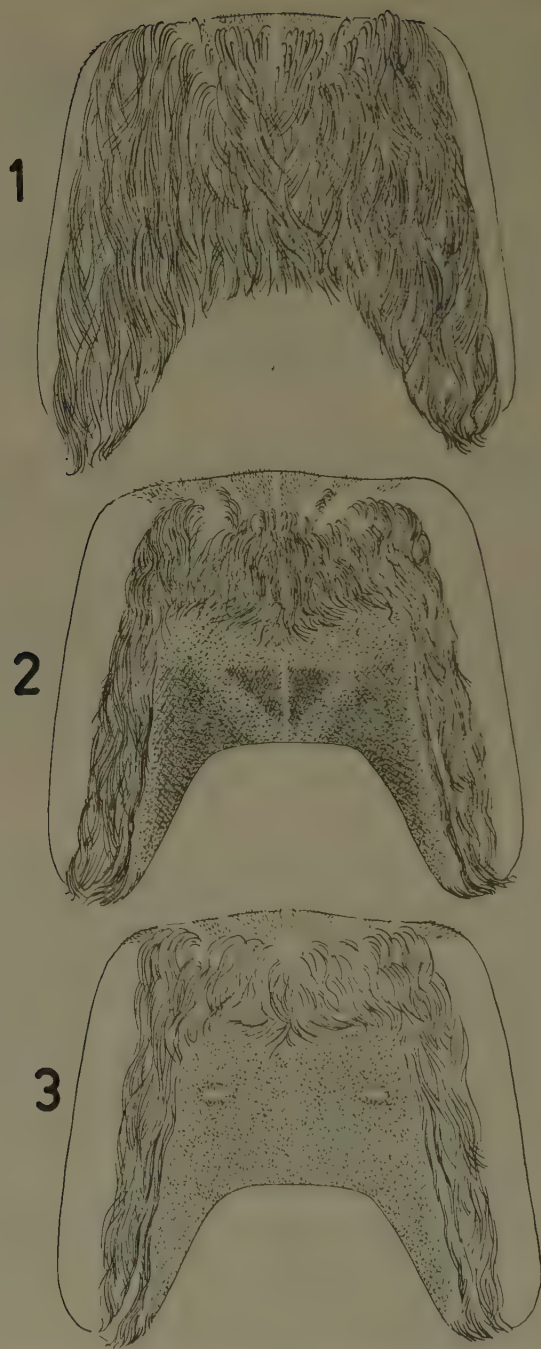
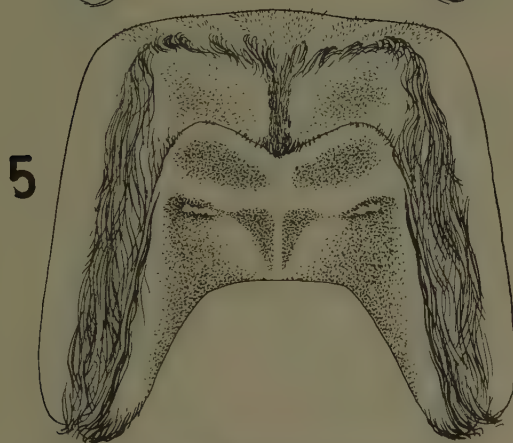
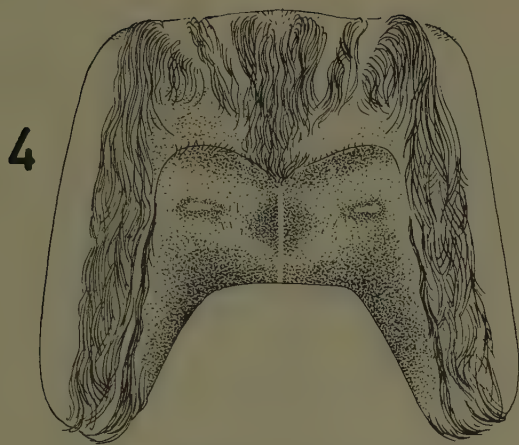


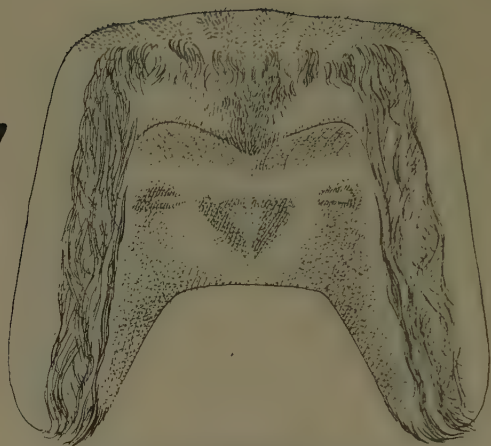
Fig. 1—9. Larva V; pterothorax dorsally: 1. *Cymatia bonsdorffi*, 2. *Corixa punctata*, 3. *Hesperocorixa castanea*,



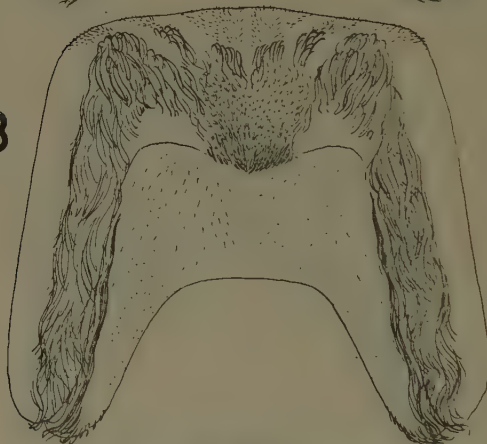
4. *Glaenocoris propinqua*, 5. *Sigara scotti*, 6. *Sigara concinna*,



7



8



9



7. *Sigara lateralis*, 8. *Arctocorisa germari*, 9. *Sigara stagnalis*.

Group II. Genus *Cymatia* (fig. 1, 11).

Mesonotum and metanotum clothed with long procumbent hairs.

Group III. Genus *Corixa* (fig. 2) and *Hesperocorixa* (fig. 3).

Metanotum without long hairs. The hair-covering on the mesonotum is both medially as laterally long and is covering the whole posterior margin. The difference between both genera probably is given in a different length-ratio of meso- and metanotum. In *Corixa*, of which only the species *punctata* could be studied, the medial length of the mesonotum is almost one and a half times the length of the metanotum. In the three species of *Hesperocorixa* investigated the mesonotum is as long as or slightly shorter than the metanotum.

Group IV. Genus *Glaenocorisa* (fig. 4).

Metanotum without long hairs. The hair-covering on the mesonotum reaching the front margin; hairs on the median field long; hind margin only medially covered with hairs.

Group V. Genus *Sigara* (fig. 5—7, 9), *Arctocorisa* (fig. 8) and *Callicorixa*.

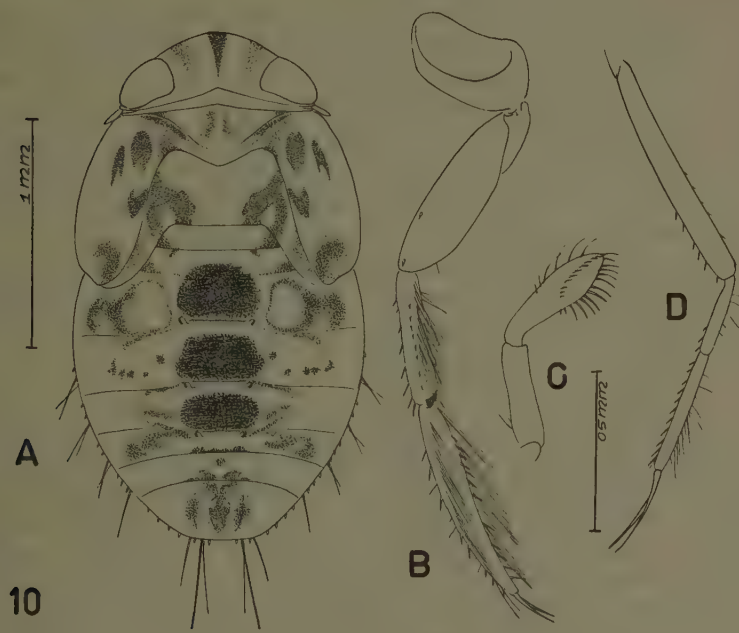


Fig. 10. *Micronecta meridionalis*, larva V; a, dorsal aspect of body; b, hind leg dorsally; c, fore leg dorsally; d, middle leg ventrally.

Metanotum without long hairs. The hair-covering on the mesonotum not reaching the front margin; hairs on the median field shorter; hind margin only medially densely covered with hairs. Within this group there appear smaller differentiations in the hair-dress. Though not very sharply separated from each other, two subgroups can be recognized:

Hair-covering on mesonotum in narrow T shape (fig. 5):  
*Sigara* (Subsigara) *fossarum*, *scotti*, *falleni*, *distincta*;  
*Sigara* (Sigara) *striata*, *semistriata*; *Callicorixa praeusta*.

Hair-covering in the middle of the mesonotum transformed into a broad field of short depressed scale-like hairs (fig. 6—9):  
*Sigara* (Sigara) *lateralis*, *nigrolineata*, *concinna*, *stagnalis*; *Arctocorixa germari*.

The metanotum in the *Corixinae* is mostly bare or with inconspicuous short brownish hairs. In *A. germari* these short hairs are more conspicuous, and in *S. concinna* and *stagnalis* very striking (fig. 6, 9).

It is interesting to follow whether the larvae of american genera can be classed in the five groups, just defined, in so far as we have detailed figures or descriptions of the haircoat-character at our disposal from literature (mentioned sub 3).

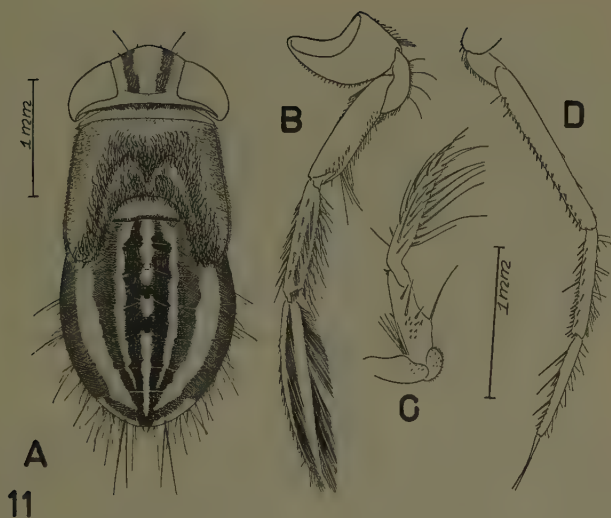
*Sigara alternata* SAY, *Palmarcorixa buenoi* ABBOTT (HUNGERFORD, 1919), *Corisella edulis* CHAMP., *Trichocorixa* spec., *Rhamphocorixa acuminata* UHLER (GRIFFITH, 1945) fall all within group V. The *Sigara* (*Vermicorixa*) *alternata* larva of GRIFFITH (op. c., recorded under *Arctocorixa*) should fall under group III according to his description; hence his identification of the larva has been wrong or the present classification of adults is not in accordance with the larval character in question.

The shape of the metasternal xiphus varies from short and obtuse with slightly convex sides to more elongated and tapered with concave sides (fig. 14a—f). These differences are the same as in the adults, but less pronounced.

#### *d. Abdomen*

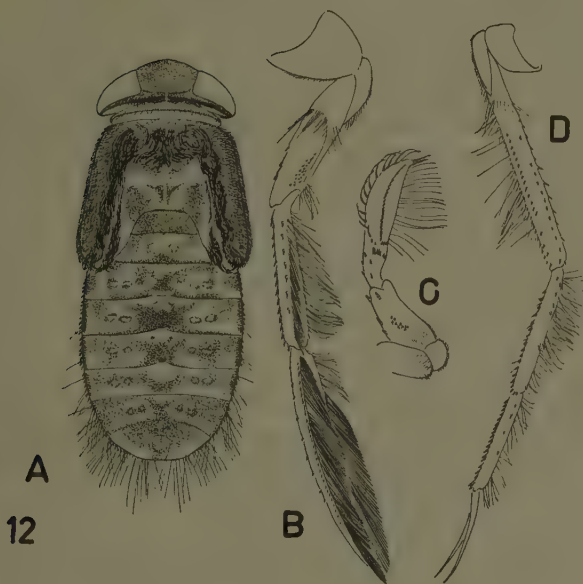
*S h a p e.* The sides of the abdomen can be nearly parallel, weakly or more strongly convex or tapering to the apex. Generally the differences are not sharp and for a key not usable. The excellent characters, which are found in the abdomen of adult males, such as differences in asymmetry of segments, strigil and genital armature, do not appear till imaginal moult. Even in the last larval instar all sternites are entirely symmetrical. Sometimes one can see the underlying adult male characters in light larvae just before the last moult.





11

Fig. 11. *Cymatia coleoptrata*, larva V; a, dorsal aspect of body; b, hind leg dorsally; c, fore leg dorsally; d, middle leg ventrally.



12

Fig. 12. *Corixa punctata*, larva V; a, dorsal aspect of body; b, hind leg dorsally; c, fore leg dorsally; d, middle leg ventrally.

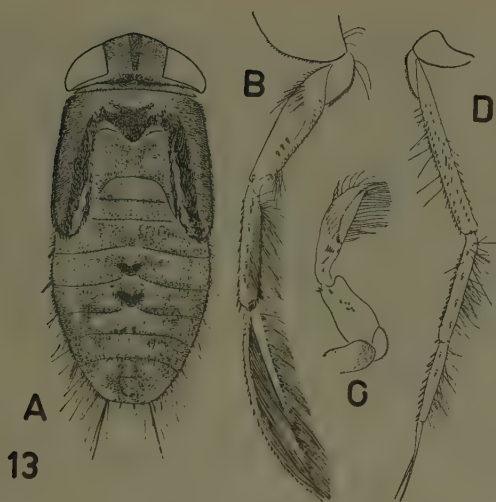
**P a t t e r n.** The colour pattern is not discriminatory for the genera but it is characteristic for a few species (for example *Cymatia coleoptrata*, fig. 11A; *C. bonsdorffi*, fig. 15; *Sigara nigrolineata*, fig. 21). Most often there is some intraspecific variation in the extent of the dark pigment and sometimes the variation is extremely great. So one may find in one and the same population of *H. sahlbergi* larvae with light and those with dark abdomina (fig. 16 and 17). It should be borne in mind that the distribution of the dark pigment is directed eunomically, that means it follows a specific pattern of the understanding that a spot which has become dark never can be light in darker coloured specimens. In a number of species the abdominal design is the same or nearly the same.

**H a i r s.** The sides of the abdomen are beset with tightly packed inconspicuous short peg-like spines and long hairs, which become more numerous and long caudad. The number and arrangement of these hairs is only in a few species as different as is pictured in fig. 12 and 13 and consequently not usable for identification. The dorsal hair-covering is mostly inconspicuously composed of short brown hairs and more caudad of long erect hairs. The short hairs are clearly marked in *S. stagnalis* and *S. concinna* because of their greater stoutness and darker brownish to blackish colour.

**D o r s a l a b d o m i n a l g l a n d s.** As generally known, corixid larvae possess an abdominal scent gland in segment 3, 4 and 5, mediolaterally of each segment concerned opening to the outside. The aperture of the two last glands is always clearly „paired”. That of the first gland is distinctly paired in the *Micronectinae* (fig. 10A) and yet clearly double in the *Cymatiinae* (fig. 11A); in the *Corixinae*, however, the opening is reduced to an inconspicuous cut (fig. 17).

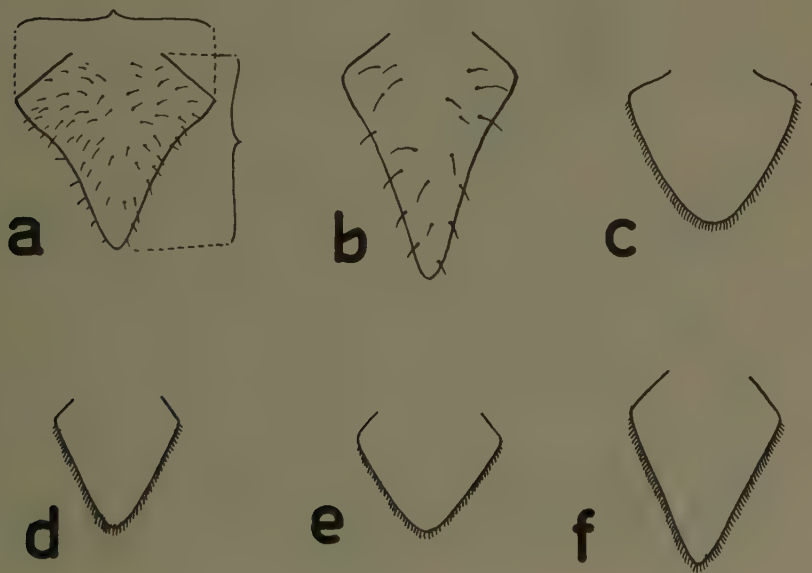
Parallel with this runs the reduction of the first gland itself. In *Corixa* and *Sigara* the first gland is vestigial (HAGEMANN, 1910; POISSON, 1924; BRINDLEY, 1929). On account of the colour of the dorsal abdominal glands, which is visible through the integument, Group V (described sub 4c) can be divided into two subgroups: on the one side there is the species combination: *S. fossarum*, *scotti*, *falleni*, *distincta*, *striata* and *semistriata* with dark brownish or blackish, sharply defined glands; on the other side: *S. lateralis*, *nigrolineata*, *concinna*, *stagnalis*, *A. germari* and *C. praeusta* with orange- or reddish coloured glands, which are less marked. Stored in alcohol for a long time the glands may shrivel and lose their colour.

*e. Legs* (for chaetotaxy see Table II).



13

Fig. 13. *Sigara stagnalis*, larva V; a, dorsal aspect of body; b, hind leg dorsally; c, fore leg dorsally; d, middle leg ventrally.



d

e

f

14

Fig. 14. Metasternal xiphus of larvae V; a, *H. linnei*; b, *H. sahlbergi*; c, *S. striata*; d, *S. semistriata*; e, *S. stagnalis*; f, *C. praeusta*.



**F o r e l e g.** The anterior leg consists of four parts: coxa, trochanter, femur and tibiotarsus. SUTTON (1947) is of the opinion that the tibia is lacking and that the last joint is composed exclusively of the tarsus. However, it is clear that it must be considered as a tibiotarsus because of the normal presence of the tibia in the adult. Furthermore the larvae of the *Corixinae* have before the hypothetical distal end of the tibia a vertical row of spines, which is homologous with the tibial cleaning comb of the middle and hind leg. As for the adults we shall call the proper tarsal part of the tibiotarsus the „pala”.

The pegs on the palae of the adult males, so important in the taxonomy of corixids, are lacking completely in the larvae, as is the pretarsal structure of the *Cymatiinae* and *Micronectinae*. The larvae of *Cymatia* can be recognized as such in that the tibiotarsus is of the original long cylindric type and the femur bears two long bristles (fig. 11c). The larvae of the species in the *Corixinae* can hardly be identified on their already typical pala-shape and- chaetotaxy. Only the fore leg of *Glaenocoris* (*Glaenocorisini*) is distinguished in shape and chaetotaxy from that of all larvae of the *Corixini*, namely: pala slender with longer bristles on the inner margin, some semi-long spines on the basal part of the tibiotarsus, and a long row of spines on the femur (fig. 24). The number of spines on the dorsal and inner side of the pala is rather constant within each species, but their differences between species is rather arbitrary and not in accordance with the genera characters (see Table II, column 1 and 2).

**M i d d l e l e g.** Differences in the variable spininess and hairiness can be established with difficulty and then still only reliable when studying many specimens; they don't lend themselves to the purpose of practical use. Ratios of length of tarsus and claw can be applied in a key with as much success as in the taxonomy of adults.

**H i n d l e g.** Both the dorsal and ventral spininess of the hind femur and the dorsal one of the hind tibia appear to be of great importance in larval systematics too. The number and the arrangement of the spines on the femur mutually and as regards those on the outer margin is in many cases specific for one or for several species (fig. 25 and 26). The number of spines along the outside of the hind tibia increases with the number of those placed dorsally.

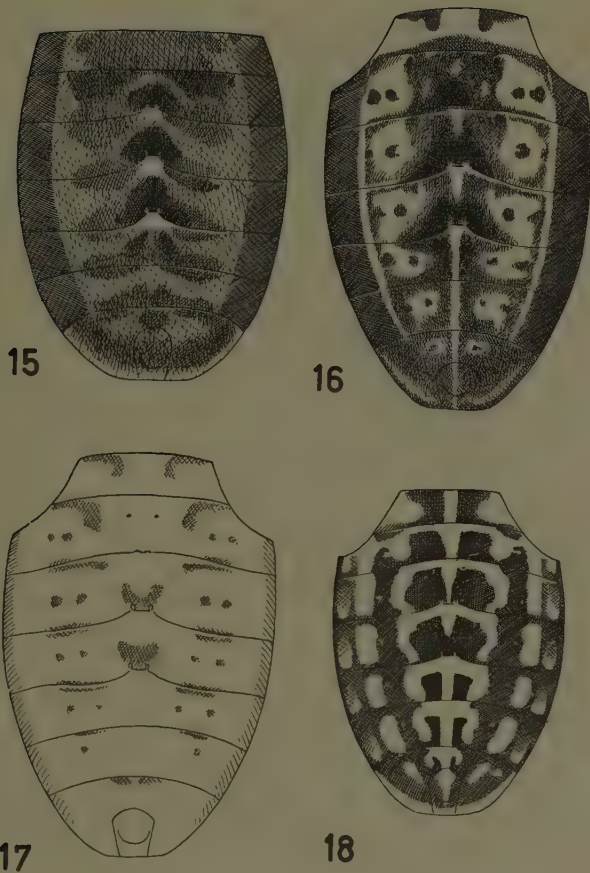


Fig. 15. *Cymatia bonsdorffi*, larva V, abdomen dorsally.

Fig. 16. *Hesperocorixa sahlbergi*, larva V, abdomen dorsally (dark extrem).

Fig. 17. *Hesperocorixa sahlbergi*, larva V, abdomen dorsally (light extrem).

Fig. 18. *Sigara striata*, larva V, abdomen dorsally.

TABLE II.

*Larvae V of Corixinae. Chaetotaxy of legs. The number of spines, which have been placed between brackets occur rarely.*

Species	bristles on pala		middle leg tarsus: claw	spines on femur 3		spines on tibia 3	
	outer side	inner side		dorsally	ventrally	dorsally	laterally
<i>G. propinqua</i>	9-10	11-14	>	ca 8	ca 8	ca 8	ca 16
<i>C. punctata</i>	15-16	15-17	± =	ca 20	ca 37	ca 7	ca 17
<i>H. castanea</i>	13-14	18-20	<	ca 20	ca 5	ca 4	ca 11
<i>H. linnei</i>	13-14	22-23	>	ca 20	ca 11	ca 4	ca 11
<i>H. sahlbergi</i>	12-13	22-23	>	1-3	ca 11	5- 7	ca 16
<i>A. germari</i>	8- 9	13-14	<	(3-4)-7	ca 5	6- 8	ca 15
<i>S. fossarum, scotti</i>	8- 9	20-22	<	(6-7)-12	ca 14	8-12	ca 12
<i>S. falleni, distincta</i>	8- 9	20-22	<	(6-7)-12	ca 14	8-12	ca 12
<i>S. striata</i>	10-12	18-20	± =	3-6(-7)	ca 8	5- 6	ca 16
<i>S. semistriata</i>	8- 9	16-18	<	2	ca 4	ca 5	ca 10
<i>S. lateralis</i>	8- 9	19-21	<	4-7	ca 8	8-12	ca 20
<i>S. nigrolineata</i>	8- 9	19-21	<	1-3	4-5	5- 6	ca 12
<i>S. concinna</i>	8- 9	14-16	± =	7 + 8	ca 35	ca 10	ca 16
<i>S. stagnalis</i>	13-15	25-29	< or =	(2-3)-5(-6)	ca 17	5- 7	ca 12
<i>C. praeusta</i>	8-9	19-21	< or =	(0)-2-4	ca 17	(4-5)(-6)	ca 16



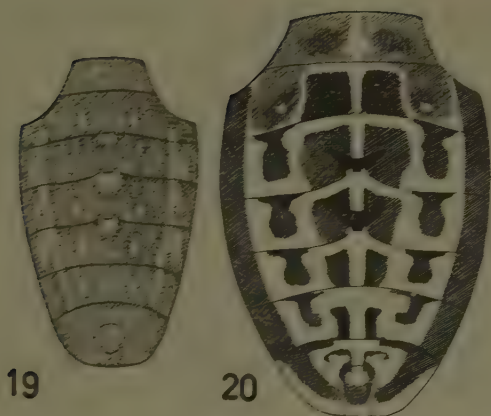


Fig. 19. *Sigara semistriata*, larva V, abdomen dorsally.  
 Fig. 20. *Sigara lateralis*, larva V, abdomen dorsally.  
 Fig. 21. *Sigara nigrolineata*, larva V, abdomen dorsally.  
 Fig. 22. *Arctocoris germari*, larva V, abdomen dorsally.

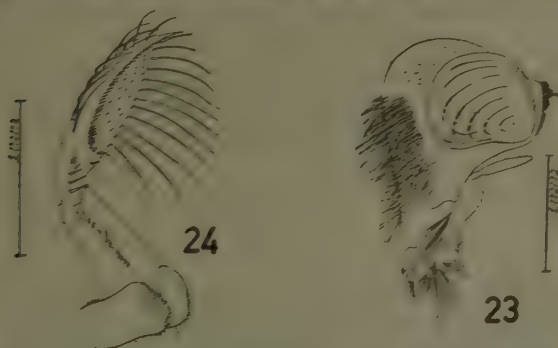


Fig. 23. *Glaenocoris propinqua*, head of larva V, lateral view.  
 Fig. 24. *Glaenocoris propinqua*, fore leg of larva V, dorsal view.

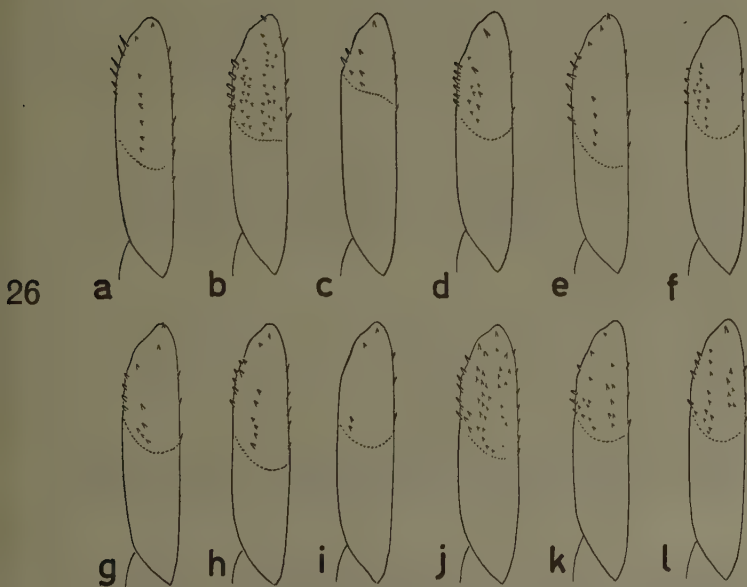
## 5. KEY TO THE LAST LARVAL INSTAR OF THE DUTCH SPECIES

Species, of which no larval material has been at our disposal, are discussed in small print. The possibility of identifying them can be estimated by extrapolation of own adult characters and those of imaginal and larval ones or related species.

- A(B) Pterothorax entirely bare dorsally. First dorsal abdominal gland as large as the two remaining; aperture very long, with two pores widely separated from each other (fig. 10A). Length LA (from the front margin of the mesonotum to the apex of the abdomen) less than 2.4 mm. Genus *Micronecta*
- B(A) Pteronotum wholly or partly covered with long hairs. Aperture of first dorsal abdominal gland short. Length LA more than 2.4 mm.
- C(D) Both meso- and metanotum covered with long hairs (fig. 1, 11A). Beak without transverse sulcations. First dorsal abdominal gland with two clearly defined pores. Tarsal part of tibiotarsus cylindrical, not shovel-shaped; fore femur with two long bristles (fig. 11C). Head large with protuberant eyes ..... Genus *Cymatia*
- 1(2) Length LA less than 3 mm. A broad lateral zone of the wingpads without hairs (fig. 11A). Design of abdomen very characteristic with five light longitudinal stripes (fig. 11A) ..... *C. coleoptrata*
- 2(1) Length LA more than 3 mm. Hairs of mesonotum almost reaching the lateral margin of wingpads. Design of abdomen as in fig. 15, with a slight eunomic variation .... *C. bonsdorffi*
- D(C) Metanotum without thick hair-covering. Beak with transverse sulcations. First dorsal abdominal gland without two clearly defined pores. Tarsal part of tibiotarsus pala-like.
- E(F) Hairs covering the whole hind-margin of mesonotum (fig. 2, 3) ..... Genus *Corixa* and *Hesperocorixa*
- 1(2) Length LA more than 8 mm. Mesonotum medially almost one and a half times longer than the metanotum. Dark markings on abdomen vague, pattern as in fig. 12 A. Hind femur dorsally with a long erect group of about 20 spines, laterally



25 Fig. 25. Femur and tibia of hind leg, larva V, dorsally.  
a, *H. castanea* and *H. linnei*; b, *H. sahlbergi*; c, *S. striata*; d, *S. semistriata*; e, *S. lateralis*; f, *S. concinna*.



26 Fig. 26. Femur of hind leg, larva V, ventrally.  
a, *G. propinqua*; b, *C. punctata*; c, *H. castanea*; d, *H. sahlbergi*; e, *A. germari*; f, *S. fossarum*; g, *S. striata*; h, *S. lateralis*; i, *S. semistriata* and *S. nigrolineata*; j, *S. concinna*; k, *S. stagnalis*; l, *C. praeusta*.

with 3, ventrally with about 37 spines; hind tibia dorsally with about 7 spines (fig. 12B-D, 26b) ..... *C. punctata*

(From the genus *Corixa* only the larvae of *punctata* could be studied. The remaining species, known from the Netherlands, are *dentipes*, *panzeri* and *affinis*. The ratio of the meso-/metanotum length, mentioned above, may perhaps appear to be characteristic for the genus *Corixa*. With the experience that typical morphological structures on the legs appear most often only in the adult stage, it is not expected that *C. dentipes*, which differs from *C. punctata* only in that it has a narrower base of the middle tibia, can be identified on that character in the larval instar. The larvae of *C. panzeri* and *C. affinis* must have a length LA smaller than 8 mm. The adults of these two species have a different number of spines dorsally on the hind femur, namely less than 15 in *panzeri* and more than 15 in *affinis*.)

- 2(1) Length LA smaller than 8 mm. Mesonotum as long as or slightly shorter than metanotum. Hind femur ventrally with less than 20 spines ..... Genus *Hesperocorixa*
- 3(4) 1—3 (generally 2) spines on upper side of hind femur in one row (the most proximal of these spines is always placed distally from the most proximal spine on the outer margin, fig. 25b). Hind femur ventrally with about 11 spines (fig. 26d); hind tibia dorsally with 5—7 and on the outer margin with about 16 spines. Metasternal xiphus distinctly longer than broad, with concave sides (fig. 14b). Abdomen marked as in fig. 16 and 17. Length LA 5—6 mm ..... *H. sahlbergi*
- 4(3) 15—20 spines on upper side of hind femur, not in one straight row (fig. 25a); hind tibia dorsally with 4—5 spines, laterally with about 11 spines. Metasternal xiphus not or scarcely longer than broad (fig. 14a). Abdomen uniform brown, without marking.
- 5(6) Length LA more than 4 mm. Claw of middle leg most often shorter than the tarsus. Hind femur ventrally with about 11 spines ..... *H. linnei*
- 6(5) Length LA smaller than 4 mm. Claw of middle leg most often longer than the tarsus. Hind femur ventrally with about 5 spines ..... *H. castanea*

(Populations of larvae of *H. moesta*, which corresponds in size with *H. castanea*, can probably be recognized in having the imaginal character: claw of middle leg most often shorter than the tarsus. The adult differences in the spininess of the hind tibia as given by HÖREGOTT & JORDAN, 1954, are wrong.)



F(E) Hairs covering only the middle of the hind margin of mesonotum (fig. 4—9).

G(H) Long hairs reaching front margin of mesonotum; hairs in the middle of the plate long (fig. 4).

Eyes protuberant, blackish. The front of the head concave, thick and with long hairs (fig. 23). Length of the 11—14 long bristles on the inner margin of the pala one and a half times the width of the pala (fig. 24). Hind femur dorsally with one straight row of 5—8 spines, laterally with about 7 spines, ventrally with one straight row of about 8 spines; hind tibia dorsally with 6—9, laterally with about 16 spines. Middle tibia and tarsus long; the tarsus distinctly longer than the claw. Design of abdomen broadly the same as in *C. punctata*, but the median line dark. Length LA 5.3—5.8 mm .....

..... Genus *Glaenocorisa*  
*G. propinqua*

H(G) Hairs not reaching the front margin of the mesonotum; those in the middle of the plate short or scale-like (fig. 5—9)  
..... Genus *Arctocorisa*, *Sigara* and *Callicorixa*

1(2) Dorsal spines on the hind femur partly grouped in the distal innercorner (about 8), partly (about 7) on one straight line more towards the middle of the femur (fig. 25f); ventrally with about 35 spines (fig. 26j).

Hind tibia dorsally with about 10, laterally with about 16 spines. Hair-covering on mesonotum as in fig. 6. Metanotum and abdomen with short, but conspicuous stout hairs. Abdomen marked as in *S. stagnalis* (fig. 13A) Length LA 4.4—5.1 mm ..... *S. concinna*

2(1) All spines dorsally on hind femur placed in one straight row, no spines in the distal inner corner. Underside of hind femur with less than 25 spines.

3(10) Dorsal abdominal glands dark-brownish with sharply defined shape and clearly outlined through the integument (this character must be studied in fresh specimens).

4(5) Design of abdomen faint (fig. 19). Hind femur dorsally with 2, rarely with 1 or 3 spines (fig. 25d), ventrally with about 4 spines (fig. 26i); hind tibia dorsally with about 5, laterally with about 10 spines; claw of middle leg longer than the

tarsus. Metasternal xiphus slightly longer than wide (fig. 14d). Length LA 3.5—4.1 mm ..... *S. semistriata*

(From the imaginal characters we conclude that the larvae of *limitata* and *venusta* will not or scarcely differ structurally from those of *semistriata*. Nothing can be predicted about the abdominal design).

5(4) Abdomen marked with a clearly defined pattern. Hind femur dorsally with 3—12 spines. Metasternal xiphus as long as or shorter than wide (fig. 14c).

6(7) 3—6, very rarely 7 spines on upper side of hind femur (fig. 25c), ventrally on the middle a group of 4—5 spines (fig. 26g); hind tibia dorsally with 5—6, laterally with 16 spines; claw of middle leg about as long as the tarsus. Pala along the dorsal border with 10—12, along the inner border with 18—20 bristles. Markings of abdomen as in fig. 18. Length LA 4.6—5.3 mm ..... *S. striata*

(The larvae of *dorsalis* are probably not distinguishable from those of *striata*. On the place of *hellensi* in this key nothing can be said. As the adult of *hellensi* is recognizable by its dorsal markings, the larva has possibly a characteristic abdominal colour pattern. From its relative *striata* it is distinguished by the smaller number of spines on the underside of the hind femur).

7(6) More than 6 spines dorsally on hind femur (7—12, rarely 6) and hind tibia (8—12). Pala along the dorsal border with 8—9, along the inner border with 20—22 bristles. Claw of middle leg distinctly longer than the tarsus. Abdominal design as in *lateralis* (fig. 20).

8(9) Length LA smaller than 4.8 mm. Lateral side of hind femur with 3, that of hind tibia with 12 spines; underside of hind femur with group of about 14 spines (fig. 26f) .....  
..... *S. fossarum* and *S. scotti*

9(8) Length LA more than 4.8 mm. Lateral side of hind femur with 4—6, that of hind tibia with 17 spines; underside of hind femur with 6—9 spines ... *S. falleni* and *S. distincta*

10(3) Colour of dorsal abdominal glands orange or reddish.

11(12) Pala with 13—14 bristles along the inner border. Sides of metasternal xiphus mostly obviously concave. Front of head rather densely covered with long hairs.

Mesonotum medio-distally with a large field of scale-like

hairs (fig. 8). Abdomen marked rather vaguely (fig. 22), sides more or less strongly tapering caudad. Metanotum and abdomen with rather distinct short darkish hairs (not so obvious as in *stagnalis* and *concinna*). Pala along the outer border with 8—9 bristles. Hind femur dorsally with 4—7 (rarely 3), ventrally with about 5 spines (fig. 26e). Hind tibia dorsally with 6—8, laterally with 15 spines. Claw of middle leg longer than the tarsus. Length LA 4.6—5.5 mm.  
 ..... *Arctocoris* *germari*

12(11) Pala with more than 18 bristles along the inner border. Sides of the metasternal xiphus not concave. Front of head with few or no hairs.

13(14) 8—12 spines dorsally on hind tibia.  
 Pala along the outer border with 8—9, along the inner border with 19—21 bristles. Hind femur dorsally with 4—10 (fig. 25e), ventrally with about 8 spines (fig. 26h); hind tibia dorsally with 8—12, laterally with about 20 spines. Claw of middle leg longer than the tarsus. Hair-covering on mesonotum as in fig. 7. Markings of abdomen as in fig. 20. Length LA 3.4—4.0 mm ..... *S. lateralis*

14(13) Hind tibia dorsally with at most 7 spines.

15(16) Metanotum and abdomen distinctly haired with short stout black hairs. Pala along the outer border with 13—15, along the inner border with 25—29 bristles. Metasternal xiphus wider than long, with strongly rounded apex (fig. 14e). Hind femur dorsally with 3—5 (rarely 2 or 6), ventrally with about 17 spines (fig. 26k); hind tibia laterally with about 12, dorsally with 5—7 spines. Tarsus of middle and hind leg with darker apex. Claw of middle leg generally longer than the tarsus and shorter than the tibia. Hairs medially on mesonotum dense and scale-like (fig. 9). Markings on abdomen as in fig. 13A. Length LA 3.8—4.5 mm .... *S. stagnalis*  
 (In view of the imaginal characters the larvae of *selecta* are probably not or hardly distinguishable from those of *stagnalis*).

16(15) Metanotum and abdomen indistinctly short-haired. Pala along the outer border with 8—9, along the inner border with 19—21 bristles. Metasternal xiphus longer than broad, not broadly rounded (fig. 14f).

- 17(18) Hind femur ventrally with about 4—5 spines. Strip of short hairs medially on mesonotum broad. Abdomen predominantly light, pattern as in fig. 21. Claw of middle leg much longer than the tarsus, generally longer than the tibia. Length LA 3.4—4.0 mm. Hind femur dorsally with 1—3, hind tibia dorsally with 5—6 spines ..... *S. nigrolineata*
- 18(17) Hind femur ventrally with about 17 spines (fig. 26 l). Strip of short hairs medially on mesonotum narrow. Abdomen predominantly uniformly brownish. Claw of middle leg shorter than or as long as the tarsus. Length LA 4.4—5.2 mm. Hind femur dorsally with 2—4 (rarely 0 or 1) spines; hind tibia dorsally with 4—6 spines ..... *Callicorixa praeusta*  
(The larvae of *wollastoni* are probably not or hardly distinguishable from those of *praeusta*).

## 6. THE FIRST LARVAL INSTAR

The first larval instar shows clear characters by which it can be placed in one of the three subfamilies:

- A(B) Body narrow with almost parallel sides. Head wider than thorax with relatively large eyes. Tibiotarsus of fore leg long and cylindrical, with very long bristles; femur of fore leg with two long bristles on the inner side .....  
..... *Cymatiinae* (fig. 27)  
(*Cymatia coleoptrata* has a clearly defined dark pattern and its dorsal surface is wholly beset with short hairs, fig. 27A).
- B(A) Body oviform. Head not wider than thorax with relatively small eyes. Tarsus of fore leg already pala-like.
- C(D) Less than 1 mm long. The three dorsal abdominal glands are large and broad, each with two widely separated pores .....  
..... *Micronectinae*  
(fig. 4 in WRÓBLEWSKI 1958, *M. meridionalis*).
- D(C) More than 1 mm long. First dorsal abdominal gland smaller than the second and third with two clearly separated pores (opp. in the last instar), which lie close together .....  
..... *Corixinae* (fig. 28).

As may be seen in the figures 27 and 28 the chaetotaxy may play the most important role in the systematics of the corixid first instars.



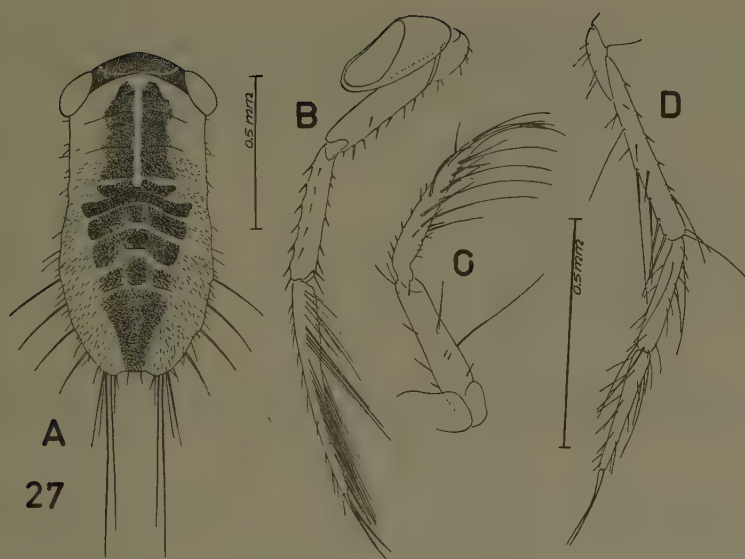


Fig. 27. *Cymatia coleoptrata*, larva I; a, dorsal aspect of body; b, hind leg dorsally; c, fore leg dorsally; d, middle leg ventrally.

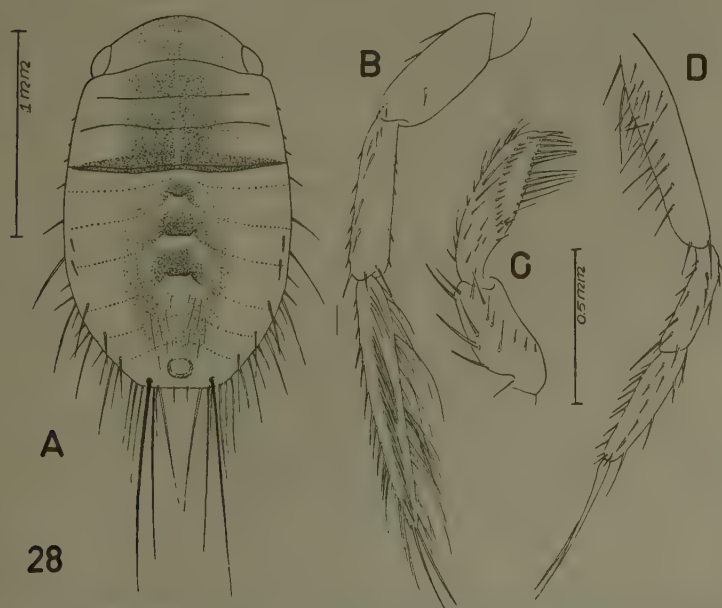


Fig. 28. *Corixa punctata*, larva I; a, dorsal aspect of body; b, hind leg dorsally; c, fore leg dorsally; d, middle leg ventrally.

TEYROVSKÝ (1925 and 1939), comparing the first instar of eight *Corixinae*, paid special attention to the hairs medio-ventrally on the abdomen. In the different species the number of hairs on the anterior border of sternit 5, 6, 7 and 8 appeared to amount:

<i>C. punctata</i> , <i>H. linnei</i> , <i>H. sahlbergi</i> :	2,	4,	2,	2.
<i>S. falleni</i> , <i>S. concinna</i> :	2,	2,	4,	4.
<i>S. striata</i> , <i>S. lateralis</i> , <i>C. praeusta</i> :	2,	2,	2,	2.

On these data alone TEYROVSKÝ (1925) thought it desirable to introduce changes in the classification valid at that time.

## 7. THE DEVELOPMENT OF DISTINGUISHING CHARACTERS AND THE POSSIBILITIES OF IDENTIFYING THE YOUNGER INSTARS

DELSARTE (1948) carried out extensive measurements on all five instars of 3 *Corixinae* and 1 *Micronecta*. He found that during the whole larval development all quantities measured increase on a geometrical progression. TEYROVSKÝ (1925) calculated ratios of parts of legs in the first two instars of some species. In the few detailed studies on the whole larval development of one species exact data on chaetotaxy of the extremities are only given by CAROLI (1925). It is not our intention to determine here whether it should be possible to key the instars I—IV of *Corixidae* up to the species or small species-groups. Suffice it to put on record the following facts, which may be of use in an eventual taxonomic investigation of the younger instars. In the *Corixinae* the numbers of spines dorsally on the hind tibia are equal in all larval instars of a given species. This is the case as well with the dorsal spines on the hind femur, except in the genera *Corixa* and *Hesperocorixa*, in which there are more spines in each succeeding instar.

## 8. DISCUSSION OF THE CHARACTERS IN RELATION TO CORIXID CLASSIFICATION

*Subfamilies.* The study of the larvae has strengthened us in our opinion that *Cymatia* belongs to a separate line of evolution, about equivalent with the *Micronectinae* on the one side and the *Corixinae* on the other side, a status proposed by HUNGERFORD (1948) and followed by STICHEL (1955) and POISSON (1957). LESTON (1955) refers to HUNGERFORD's extensive criticism of the lumping classification of WALTON, but nevertheless he reduced the rank of *Cymatiinae* HUNGERF. to tribal status. He does so on account of a super-

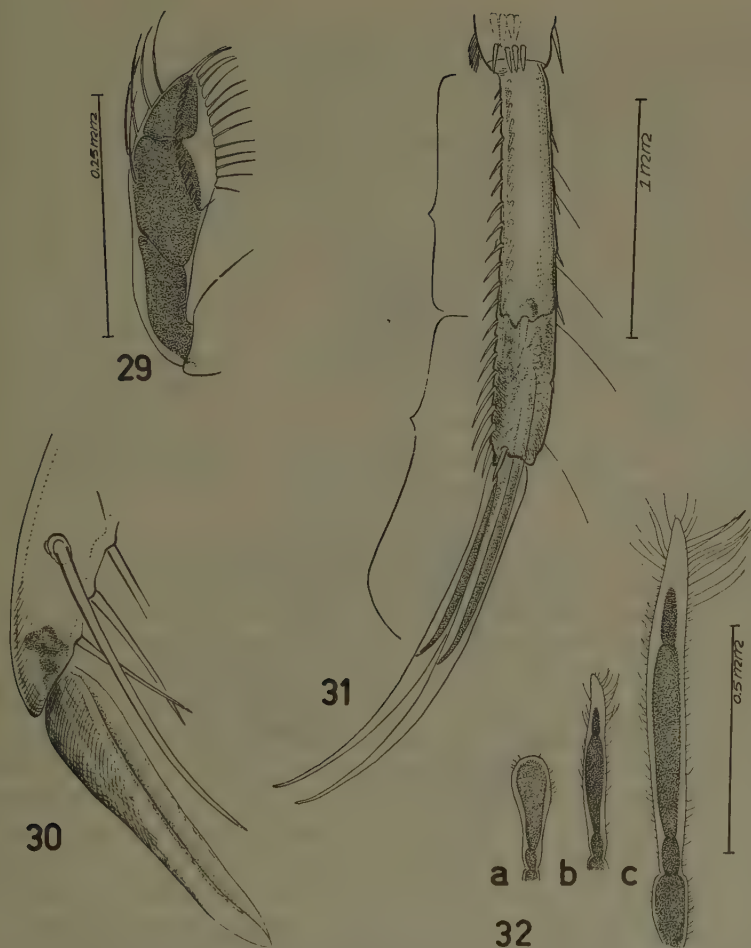


Fig. 29. *Micronecta meridionalis*, tibio-tarsus of larva V, ♂; within it the development of tibia, pala and metatarsal structure of the adult is shown.

Fig. 30. *Cymatia coleoptrata*, adult male; metatarsal structure of anterior leg.

Fig. 31. *Corixa punctata*, larva V, female; apex of middle leg; accolade shows the development of tarsus and claws of the adult.

Fig. 32. Antenna of larvae V; within the terminal segment the increase of antennal joints in the adult is shown. a, *Micronecta meridionalis*; b, *Cymatia coleoptrata*; c, *Corixa punctata*.

ficial comparison of only a few characters. He conceals for example the structure of the hemielytra, whereas HUNGERFORD (op. c.) considers these structures among others as of subfamily significance. The close examination of the imaginal characters shows that the *Corixidae* of the temperate zone of the northern hemisphere can be divided into 3 groups, which have developed in phylogenetically different ways. It has grown into a custom to point out the great difference between the eggs of the *Micronectinae* on the one side and those of the *Cymatiinae* and *Corixinae* on the other. But so long as the eclosion of the *Micronecta*-egg is not yet studied, this difference is only seemingly great. It applies only to an atypical shape and a lateral attachment on the substrate (possible adaptation of oviposition on stones etc. in deeper water or other environmental conditions). In this connection attention is drawn to the totally different figuring of the egg of *M. meridionalis* by POISSON (1933, fig. 31, with numerous long filaments) and by WRÓBLEWSKI (1958, fig. 3, without filaments).

In some as it seems important respects the differences between the *Cymatiinae* and the *Corixinae* are even greater than those between the *Micronectinae* and the *Corixinae*. The beak is furrowed in the latter two groups, which are mainly detritus-feeders, and the fore tarsus is transformed into the characteristic pala. In the mainly carnivorous *Cymatiinae* the beak is not furrowed, and the fore tarsus has retained its original cylindrical form. On the other hand the unpaired flexible terminal structure on the male fore leg is met with both in *Cymatiinae* and *Micronectinae*. This structure is generally considered as being the claw. When one studies the development of the adult fore leg of a *Micronecta* male within its last larval skin (fig. 29), one is at first inclined to think that the tarsus is subject to division into two segments; this should point to a primitive character. The flexible end structure in the adult however is smooth and entirely hairless. A comparison with the point of implantation and articulation on the tarsus in a *Cymatia* adult (fig. 30) and the development of the middle tarsus in *Corixa* (fig. 31) shows clearly that the terminal joint in *Micronecta* and *Cymatia* represents a pretarsal structure. Also the australasian *Diaprepocorinae*, which are considered as the most primitive corixids (ocelli present), possess a large appendix on the fore leg. Maybe this structure serves as a grasping-apparatus during copulation. On the other hand its function as a smear-apparatus is not unimaginable. BENWITZ (1956) discovered in the *Corixinae* that the epithelium of the claw-flexor nerve of all pairs of legs is transformed into a gland, which in her opinion possibly supplies a secretion for smearing the body integument. This gland is most highly developed in the anterior leg.



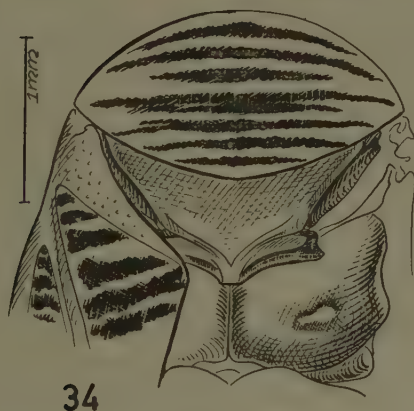
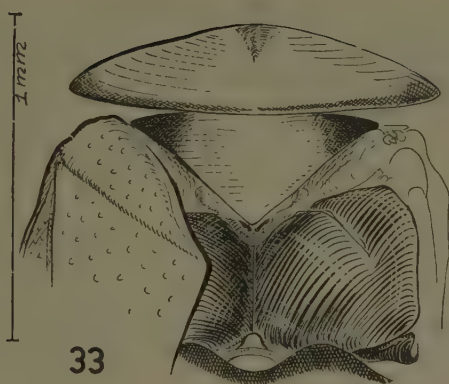


Fig. 33. *Cymatia coleoptrata*, adult; thorax dorsally; right hemielytron removed; pronotum and left hemielytron turned somewhat to the front and to the left in order to show the arrangement of scutellum and metathorax.

Fig. 34. *Sigara falleni*, adult; as in fig. 33.

The *Corixinae* bear on top of the pala one single well developed claw with basally a small organ, to which WEBER (1930, p. 101, fig. 84) and POISSON (1951, fig. 1516) ascribe a chemoreceptor function without however giving conclusive evidence. BENWITZ (l.c.) does not mention this organ, but its position makes it clear that it connects the gland described by her. Very probably it must be considered as homologous (arolium?) with the praetarsal structure of *Cymatiinae* and *Micronectinae*. This means that in the last two subfamilies, which have in several respects a primitive nature, the differentiation of the praetarsus has gone far further than in the *Corixinae*. The presence of the abdominal male strigil seems not to

run parallel with the praetarsal differentiation (absent in *Cymatiinae*, mostly present in *Micronectinae* and *Corixinae*), and the male abdomen is asymmetrical in all three subfamilies.

The scutellum is visible only in the *Micronectinae*. The scutellum of *Cymatia* (fig. 33) has the same simple triangular shape as *Micronecta*, whereas in the *Corixinae* (fig. 34) it is fused with the pterothorax.

The three dorsal abdominal glands are functional in all instars of *Cymatia* and *Micronecta*. The first gland in the *Corixinae* is subject to reduction from instar one to five. Another larval character that during the postembryonic development is retained at longest in *Cymatia* and *Micronecta* concerns the two pairs of long blackish bristles on top of the abdomen.

*Genera.* The subdivision of the *Corixinae* is debated so many times in the literature that here we do not revert to it in extenso. As the study of the larvae within the genus *Sigara* has shown groups which do not completely correspond with the present-day division into subgenera, we have applied in the present paper only the splitting in *Sigara* and *Subsigara*. The care in this, for which MACAN (1955) urged, still remains in force, as the conceptions on the genera and subgenera are not stabilized uptill now. Thus for example POISSON (1957) is following a questionable and very confusing procedure when he raises the monotypical subgenus *Paracorixa* STICHEL 1955 into a genus whereas at the same time he remarks that there is no objection to class its genotype *concinna* under *Sigara*, subg. *Vermicorixa* (p. 75: „Dans cette alternative, *Paracorixa* tomberait en synonymie avec *Vermicorixa*”).

## 9. ACKNOWLEDGMENTS

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# Le facteur pression et les réactions cardiaques chez les Poissons téléostéens d'eau douce

par

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Dans le milieu aquatique, les facteurs physiques et chimiques (salinité, pH, courants, lumière, température etc. . .) jouent un rôle de premier plan dans la répartition des organismes et dans les migrations.

Le facteur pression, en particulier, présente des variations énormes, en rapport avec la profondeur du milieu.

Ces fortes variations de pression sont d'autant plus intéressantes pour le biologiste que les êtres vivants y sont constamment soumis. Chez les Poissons, la ligne latérale antérieure et postérieure est innervée par la quatrième branche du nerf vague, la troisième se divisant en deux, pour innerver d'une part, les troisièmes et quatrièmes arcs, et d'autre part, les régions gastriques et cardiaques. L'ensemble du système latéral comprenant la région céphalique et postérieure serait très sensible, même aux vagues produites à la surface du milieu par le vent, ou aux troubles provoqués dans l'eau par la chute des objets. Il est certain que ce sens des "mouvements de l'eau" est bien particulier aux Poissons. Ces derniers sont même capables de détecter la proximité d'un rocher ou d'une berge par différence de pression. C'est alors que nous nous sommes demandés:

- 1° Quelles étaient les répercussions de ces variations de pression sur l'activité cardiaque des Poissons.
- 2° Quelles étaient les zones particulièrement sensibles à ces manifestations.

## TECHNIQUE ET DISPOSITIF EXPERIMENTAL

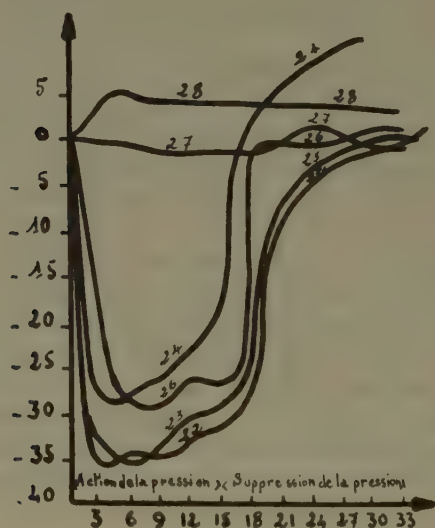
Nous avons opéré sur une trentaine de Carpes (*Cyprinus carpio* L., variété cuir) et une quinzaine de Barbeaux (*Barbus fluviatilis* Cuv.).

Nos expériences ont été effectuées pendant les mois d'Avril, Mai et Juin 1959, et les températures ont varié entre 13° et 15°5.

Les sujets étant placés dans un aquarium rempli d'eau aérée par un bell-bull, la pression est effectuée au niveau de la ligne latérale céphalique et postérieure.

Utilisant un compas d'épaisseur de grande dimension, garni, au niveau des pointes recourbées dans le sens perpendiculaire à l'axe de l'animal, de bouchons de caoutchouc, nous avons à volonté, en faisant varier l'écartement, comprimé plus ou moins des zones précises. La valeur de la pression exercée a été déterminée empiriquement grâce aux graduations repères lues sur le compas.

Les réactions baro-cardiaques ont été enregistrées à l'électrocardiogramme Beaudouin.



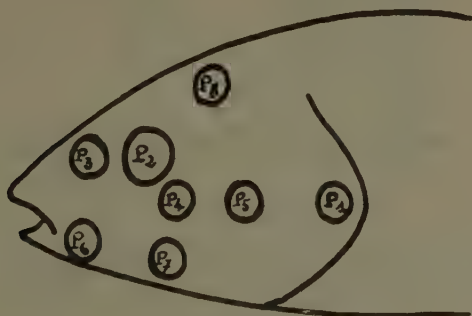
Graphique I

*Cyprinus carpio* L. - Influence de la pression au niveau arrière de la région operculaire sur le rythme cardiaque - T° 13°5 - Poids 300 g - Aération par bell-bull - Luminosité 60 watts par éclairage indirect. Durée des pressions 15 minutes - Intensité des pressions exprimée en mm lus sur le cadran repère du compas: les écartements les plus importants correspondant aux faibles pressions. En abscisse: variations différentielles des fréquences cardiaques. En ordonnée: temps exprimé en minutes.

## INFLUENCE DE L'INTENSITE DES PRESSIONS LATERALES

Des pressions bilatérales effectuées durant quinze minutes au niveau de la ligne latérale soit postérieure, soit céphalique, déterminent une bradycardie réflexe d'autant plus prononcée que la pression est plus importante (voir graphique n° 1 relatif à la Carpe cuir n° 270.459). Les pressions sont exercées au niveau de la ligne latérale, juste en arrière des opercules. L'ablation complète et bilatérale du nerf latéral postérieur, dans cette région, fait disparaître ce réflexe cardiaque. De même, une compression trop importante provoquant une lésion profonde de cette zone, empêche tout effet cardio-vagal de se produire. L'effet bradycardique est donc bien d'origine nerveuse.

Des pressions, exercées dans des régions autres que celles où aboutissent ces terminaisons sensorielles, sont pratiquement sans grand effet bradycardique. En particulier, la région céphalique se prête bien à ce genre de réflexe, parce que les terminaisons du trijumeau sont aisées à repérer.

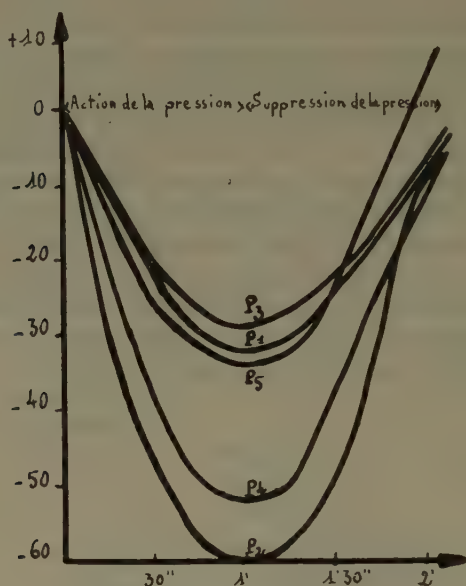


- Schéma n° 1 montrant les points de la région céphalique où ont été exercées les pressions.

En effet, nous nous sommes efforcés de comprimer de façon aussi semblable que possible, les zones d'émergence des ramifications parasympathiques de la région céphalique (voir schéma n° 1, un numérotage correspond aux zones comprimées).

Chez la Carpe miroir, comme chez le Barbeau, l'intensité des réactions observées pour une pression donnée, est d'autant plus importante que l'on se trouve plus proche des régions les plus sensibles. En particulier, dans la région céphalique, chez la Carpe miroir, la zone la plus réactive est celle des globes oculaires (P<sub>2</sub> et des régions parcourues par le trijumeau et ses branches (voir graphique II relatif à la Carpe n° 130.559).

Le tableau ci-dessous indique pour les 12 Carpes étudiées les valeurs moyennes de l'abaissement des fréquences cardiaques, par minute, et pour une minute de compression.



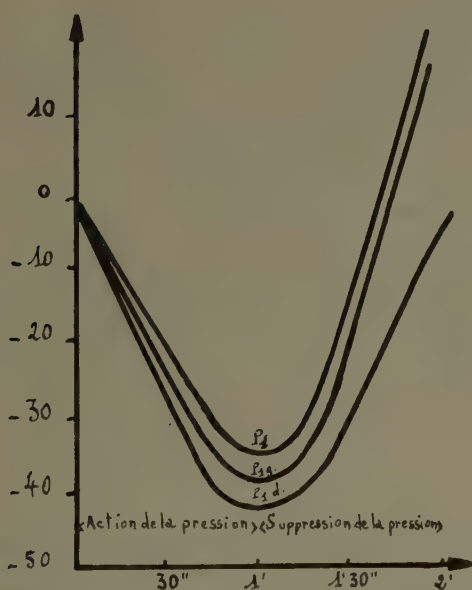
Graphique II

*Cyprinus carpio* L. – Influence des pressions d'intensité équivalente exercées en différents points de la région céphalique, sur le rythme cardiaque. Points excités P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>, P<sub>4</sub>, P<sub>5</sub>, – Durée de l'excitation 1 minute – En abscisse: variations différentielles des fréquences cardiaques; en ordonnée: temps exprimé en minutes.

Zones	Abaissement	Valeur du coefficient "r" par rapport à P <sub>2</sub>
P <sub>2</sub> (globes oculaires)	56	néant
P <sub>4</sub> laires)	50	1,02
P <sub>6</sub>	49	1,04
P <sub>7</sub>	47	1,3
P <sub>5</sub>	45	2
P <sub>1</sub>	34	5,1
P <sub>3</sub>	27	5,8



Les activités vagales des différentes parties de la région céphalique, vont donc en s'amenuisant, comme cela vient d'être montré dans les graphiques et le tableau ci-dessus. On peut penser qu'il existe un gradient vagal, ayant pour origine la région oculaire, et allant en diminuant vers les zones périphériques, exception semble-t-il pour la région maxillo-inférieure. Ce gradient suit en gros les branches du trijumeau. L'existence d'un tel gradient explique pourquoi les différences d'activités vagales sont peu importantes et peu significatives entre deux régions voisines. Par contre, ces différences sont d'autant plus élevées, que les régions céphaliques considérées sont éloignées les unes des autres, ainsi que le montre le calcul des valeurs du "t" de STUDENT relatif aux moyennes des différentes régions céphaliques, en particulier  $P_1 - P_3 - P_8^*$ .

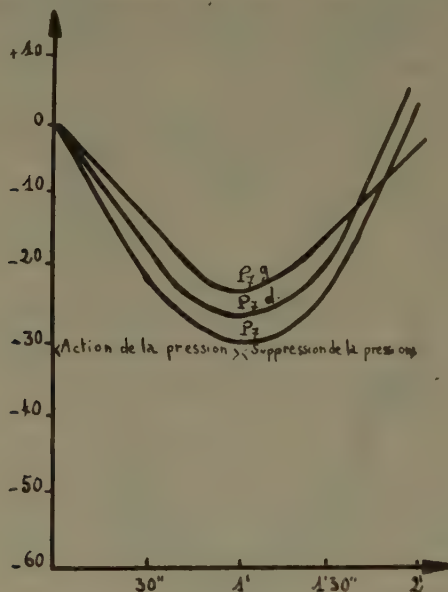


Graphique III

*Cyprinus carpio* L. — Influence de la pression sur le rythme cardiaque. Comparaison de l'influence des pressions au niveau du point  $P_1$ . Pressions unilatérales:  $P_1$  gauche et  $P_1$  droit, et pression bilatérale  $P_1$ . En abscisse: variations différentielles des fréquences cardiaques; en ordonnée: temps exprimé en minutes.

\* La position de  $P_8$  n'est guère favorable aux pressions. Des pressions exercées même au doigt n'ont jamais donné de bradycardie réflexe.

Dans un autre ordre d'idée, et pour des intensités de pression équivalentes, l'excitation unilatérale semble presque aussi importante que l'excitation bilatérale (voir graphiques III et IV relatifs au Barbeau n° 240.659 et à la Carpe miroir n° 20.659). Ces faits sont à rapprocher de ceux de THESEN & KOLFF (cités par SKRAMLIK 1935), qui rapportent que le nombre de pulsations par minute augmente après section du vague, et que si l'un des vagues est sectionné d'abord, la suppression du second ne provoque pas toujours une nouvelle accélération du coeur.



Graphique IV

*Barbus fluviatilis* Cuv. — Influence de la pression sur le rythme cardiaque. Comparaison de l'influence des pressions au niveau du point  $P_7$ . Pressions unilatérales:  $P_7$  gauche,  $P_7$  droit, et pression bilatérale  $P_7$ . En abscisse: variations différentielles des fréquences cardiaques; en ordonnée: temps exprimé en minutes.

Il semble aussi qu'il y ait peu de différence appréciable entre l'excitation portée du côté gauche et celle appliquée du côté droit. Cette constatation n'est pas en opposition avec les effets différents du vague cardiaque droit et gauche, parfaitement mis en lumière par JULLIEN & RIPPLINGER en 1957, car toute excitation droite ou gauche d'ordre périphérique, passe par le centre bulbaire, avant d'exciter obligatoirement les branches cardiaques du vague.

D'une manière plus générale, des excitations d'égale intensité produisent des effets plus durables chez le Barbeau que chez la Carpe; le Barbeau, sujet de fond, serait-il moins adaptable aux variations de pression?

### CONCLUSIONS

Chez le Barbeau fluviatile et la Carpe miroir:

- 1° des pressions mécaniques exercées au niveau du système latéral, déterminent une forte bradycardie réflexe d'origine vagale.
- 2° le réflexe oculo-cardiaque est d'une particulière netteté. L'importance de ce réflexe semble aller de pair avec le développement du trijumeau qui est très important chez les Poissons.
- 3° les zones les plus sensibles aux pressions sont celles qui reçoivent les émergences parasympathiques les plus nombreuses.
- 4° le réflexe baro-cardiaque est lié à l'intensité du facteur mécanique.
- 5° il ne semble pas y avoir de différence entre les effets produits par l'excitation unilatérale droite ou gauche et bilatérale.

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# Plankton Rotatoria in Japanese Inland Waters <sup>1)</sup>

by

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(Otsu Hydrobiological Station, Kyoto University)

## INTRODUCTION

Since a decade when our knowledge of the rotatorian fauna of Japanese inland waters was very scanty, the writer has engaged in the investigations of them. As a result, he has succeeded in determining more than 210 species of rotifers, which belong to 4 orders, 13 families and 45 genera. In the present paper, they are enlisted first in table II under a taxonomic arrangement which depends on the system offered by PENNAK (1953), and then some noteworthy species are described. In the following sections, an analysis is made in regard to the elements in the composition of the Rotatorian fauna of Japan. The discussions of morphological variations and of seasonal successions of some species in Lake Biwa-ko are done as a background for such an analysis. For this study, the author has examined a considerable number of specimens not only collected by himself, but also those which are preserved in the Otsu Hydrobiological Station where he is a research staff. The former are, for the most part, the samples which were obtained by the staff of the laboratory, including him, when the limnological surveys of Japanese lakes were made. The principal localities surveyed are distributed in the prefectures, such as Aomori, Nagano, Shiga and Kyoto. The rest specimens came from the plankton samples collected by the staff of the laboratory, since its foundation in 1914, in various localities in Japan. The more than 200 localities, where the collections were made, are distributed in almost all parts of Japan, from Hokkaidô to Kyûshû. The samples examined are as many as 1523 (Table I), most of which were col-

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1) A contribution from the Otsu Hydrobiological Station, Kyoto University.



lected for the purpose of plankton studies. They also contained not a few temporal plankters which usually dwelt in the littoral regions of lakes. On the following pages, the Rotifers found in those samples are recorded, though scanty in sessile and bdelloid forms. As an identification of soft-bodied rotifers is very difficult or often impossible only when the preserved specimens are examined, the records of such animalcules, e.g., members belonging to Notommatidae and Philodinidae, appear in the present paper as less common ones than those well-loricated.

For the discussion of distribution, Japan is conveniently divided into nine districts, namely, 1) Hokkaidô or northern, 2) Northeastern, 3) Central mountainous, 4) Eastern Pacific coast, 5) Central, 6) South-western Pacific coast (including the Inland Sea coast), 7) North-eastern Japan Sea coast, 8) Western Japan Sea coast, and 9) Kyûshû or western district. The boundaries between these districts and the localities where the collections were made are shown on the sketch map (Fig. 1). The boundary lines are in most cases coincident either with the mountain ranges or with the channels. The density of distribution of the localities is either large or small as the district differs. The frequency of the collections made at any locality is also fairly unequal. Besides the species determined by the writer himself, the records made by the preceding investigators from Japan are also added to the list of species (Table III).

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## 1. LIST OF THE JAPANESE SPECIES OF ROTATORIA

In the table III are enlisted the rotifers recorded from the inland waters of Japan. The occurrences of the species in a district, which is indicated on the top of the column, are shown with a mark +, and the records by other investigators are shown with an asterisk\*. The species number put in parenthesis shows those which could not be examined by the writer himself.

## 2. THE TAXONOMIC AND ZOOGEOGRAPHICAL ANALYSIS OF THE ROTATORIAN FAUNA OF JAPANESE INLAND WATERS

There are some noteworthy rotifers in the list of Table III. They may be classified into four categories. The first contains the rare or

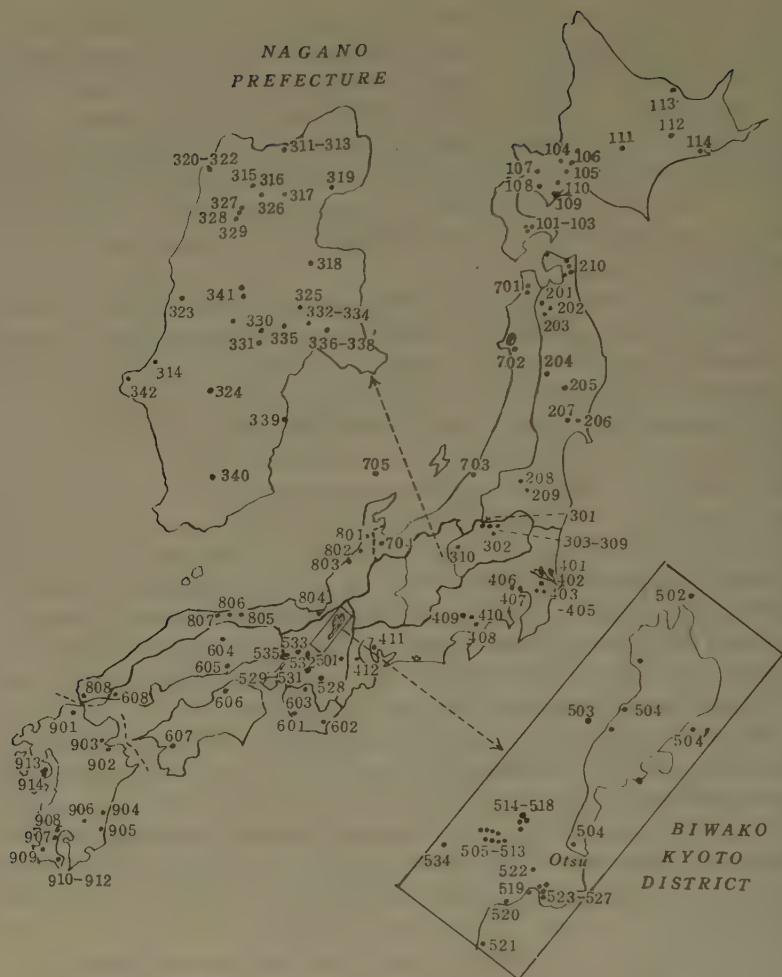


Fig. 1. Sketch map of Japan, showing the localities where the plankton samples were collected.

Nagano Prefecture and the Biwako-Kyoto District are enlarged.

I 101—114, II 201—210, III 301—342, IV 401—412, V 501—535, VI 601—608, VII 701—705, VIII 801—808, IX 901—914.

unusual species; the second includes noteworthy ones in the status of their distribution; the third comprises those which are characteristic of brackish waters; and, the fourth consists of those which show marked morphological divergence.

## A. Analyses of the faunal elements

The Rotatorian fauna of Japan will be constituted by the four elements. So far as the geographical distribution is concerned, the occurrence of any species in any longitude does not become a grave subject of discussion, with the exception of a few species. Both the latitudes and altitudes are important to be discussed; that is to say, the water temperature may be one of the important environmental factors responsible for the status of distribution, if other conditions are fundamentally similar. Thereby, the majority of the rotatorian species may be roughly classified in five categories as to their geographical distribution, i. e., frigidopolitan, subfrigidopolitan, tropicopolitan, subtropicopolitan and temperate cosmopolitan. If the temperature may be a main factor limiting the distribution, the seasons have come to the main matter of discussion. It is, therefore, not an unusual case that any austral or boreal elements are found in the temperate region and vice versa.

### a. Ubiquitous or cosmopolitan species

As already stated, most members of Rotatoria are known to show the universal distribution, and they will occur anywhere if environmental conditions are suitable for them. Only a few species are known to be confined either to the New World or to the Old World; for instance, *Brachionus havanensis* in the former and *Brachionus* (*Schizocerca*) *diversicornis* in the latter. Nevertheless, the occurrence of some species, which have hitherto been reported only from the New World, has been detected in the course of the present study (e.g., *Brachionus angularis* var. *chelonis* and some Lecanean species). Among the cosmopolitan species, those which are widely distributed in Japan are listed in Table IV.

The majority of these species occur as members of pelagic plankton. There seems to be a tendency that the wider becomes the distribution area, the larger is the occurrence rate of pelagic species.

### b. Boreal or cold-water species

#### 1. *Kellicottia longispina* (KELLCOTT, 1879)

As plotted on the sketch map (Fig. 2), the distribution region of the present species is confined to the northern part of Japan, and had been discussed by the author in 1959 as follows. *Kellicottia longispina* (KELLCOTT) is a Brachionid rotifer, which is widely distributed throughout the Northern Hemisphere. In our country, however, the localities where the present species occurs are not recorded plenty enough, as shown in figure 3. The quantitative samplings of it were carried out only in four lakes, i.e., Lakes Aoki-ko, Kizaki-ko,

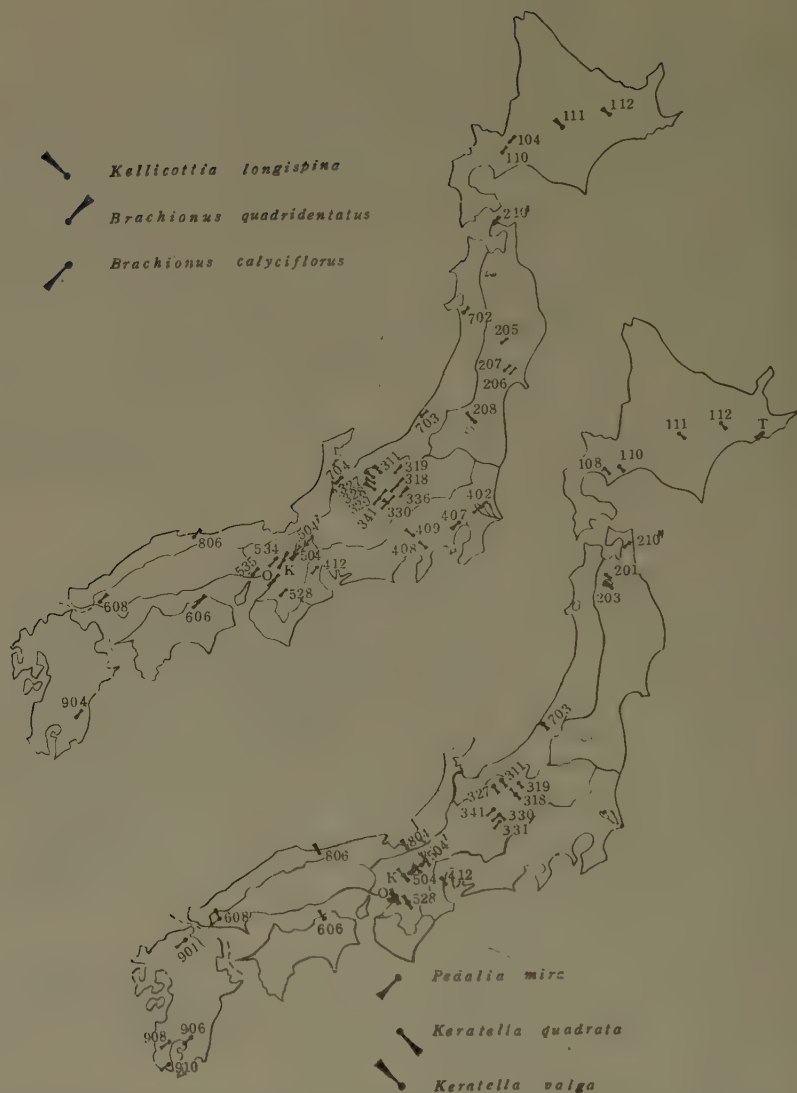


Fig. 2. Sketch map of Japan, showing the distribution of some Rotatorian species. Upper: *Kellicottia longispina*, *Brachionus quadridentatus*, *Brachionus calyciflorus*. Below: *Pedalia mira*, *Keratella quadrata*, *Keratella valga*.

T: Tokotan (Hokkaidô), K: Kyoto, O: Osaka. K for *Br. quadridentatus*: 509, 511, 514, 520, 522, 527. O for the same as above: 531. K for *Br. calyciflorus*: 508, 509, 511, 514, 515, 519, 520, 525, 527. O for the same as above: 530. K for *Keratella quadrata*: 511, 513, 519, 520, 523, 527. O the same as above: 530, 531. K for *K. valga*: 524. O for same as above: 529, 530. O for

*Pedali mira*: 529, 210': Ômazaki, 210'': Taka-numa 504': Soné-numa.



Nojiri-ko and Shikaribetsu-ko. So far as these four examples are concerned, the following characteristics may be given in regard to the distributing conditions of *Kellicottia longispina*.

When the lakes show the direct stratification of temperatures, the mode of its vertical distribution exists in the hypolimnion; more exactly saying, it is in the clinolimnion (fig. 4). Sometimes, the present species occurs either in the metalimnion or in the epilimnion, though very poor in quantity. The median value of water temperature observed at the depth where the mode appears is 7.7°C ( $\pm 0.7^\circ$ ). Were the depths insufficient, higher temperatures would be observed as in the case of the St. II of Kizaki-ko.

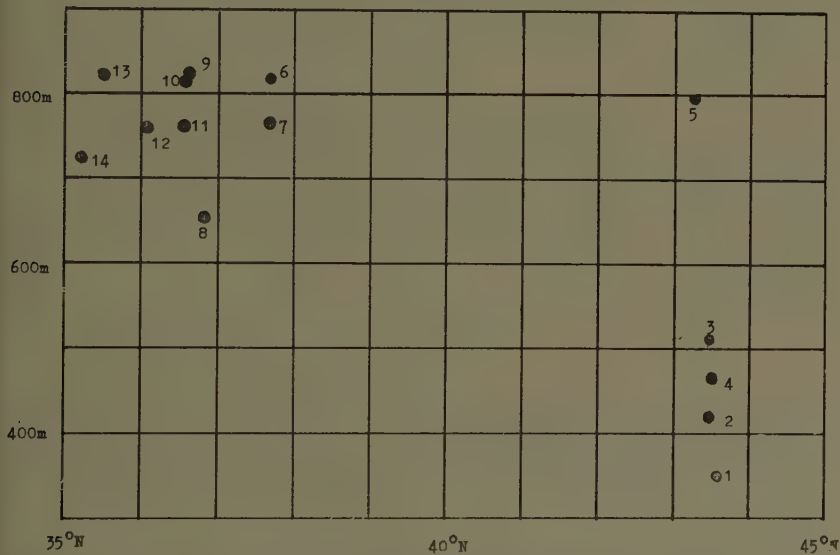


Fig. 3. The correlation of the localities between altitude and latitude.

1: Lake Mashû-ko, 2: Lake Akan-ko, 3: Lake Penke-ko, 4: Lake Panke-ko, 5: Lake Shikaribetsu-ko, 6: Lake Hibara-ko, 7: Lake Onogawa-ko, 8: Lake Nojiri-ko, 9: Lake Aoki-ko, 10: Lake Nakatsuna-ko, 11: Lake Kizaki-ko, 12: Lake Suwa-ko, 13: Lake Kawaguchi-ko, 14: Lake Ashino-ko.

Lakes and ponds of our country, where *Kellicottia longispina* occurs, are located in the districts north of 35°N. It shows an inclination that the higher the latitude becomes, the lower the altitude of lake surface will do (fig. 3). Most of the lakes where the present species is distributed have either considerable dimensions or pretty large depths, but there are several exceptions, such as Hyotan-numa of the Akan lake group, and Nakatsunako, one of the Nishina three lakes. In both cases, however, there are some lakes that stand close to them

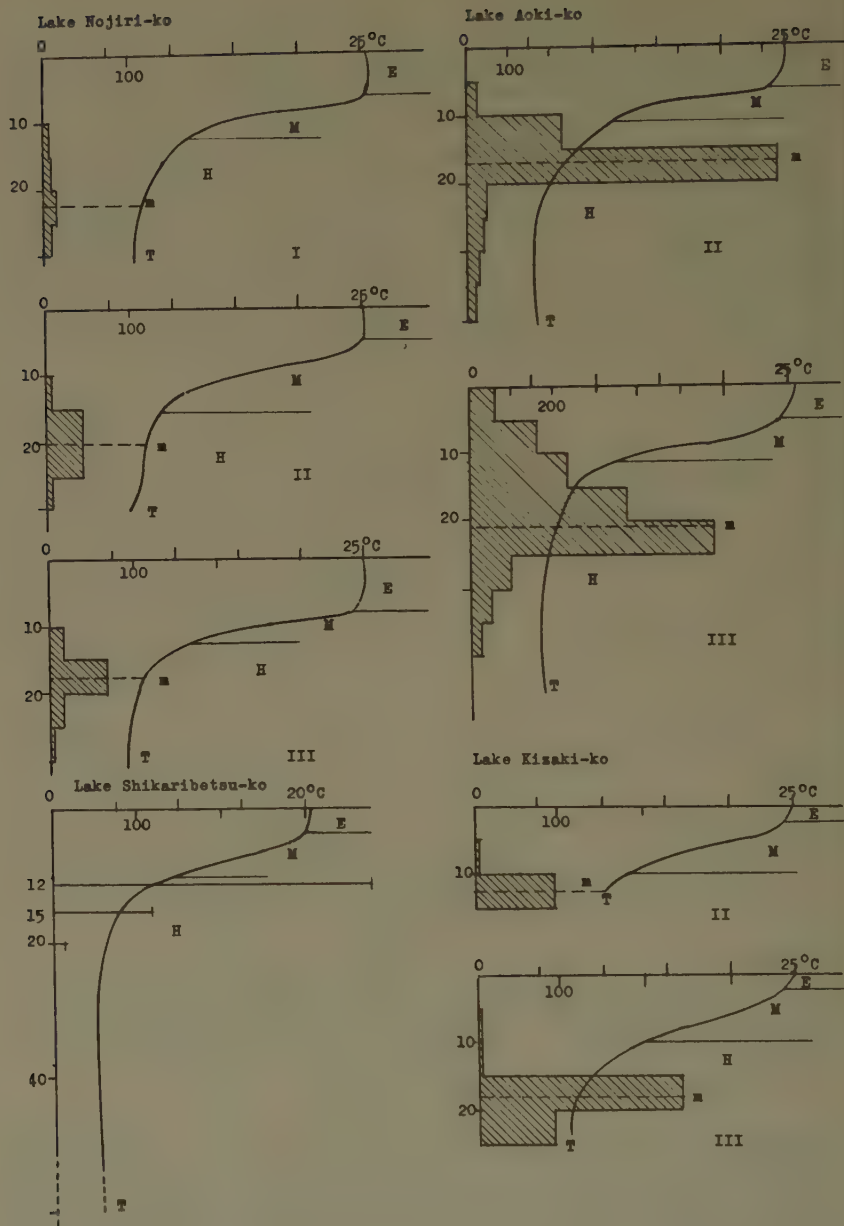


Fig. 4. The biozones of *Kellicottia longispina* in four Japanese lakes. Ordinate: Depth in metre; Abscissa: Temperature of water, degree in C., and the number of individuals of *Kellicottia*.

T: Curve of water temperature; E: epilimnion; M: metalimnion; H: hypolimnion; m: the position of mode.

and seem to be suitable for the occurrence of *Kellicottia longispina*.

The pH values of lakes range between 6.3 and 7.8. The results of quantitative samplings made vertically show that the most suitable values of pH for it are observed between 6.8 and 7.0.

2. *Keratella quadrata* (O. F. MÜLLER, 1786).

The distribution area of this species is considerably wider than that of the above species (Fig. 2). It occurs commonly in the central district and eastwards, but is fairly seldom in the district on the Pacific coast. The climate of the last-named district would be strongly influenced by the warm current „Kuroshio”. The morphological variations of the present species seem to be quite tolerable to the habitat conditions, so that the contemplations of its form will be discussed in the later section.

3. *Brachionus quadridentatus* HERMANN, 1783

(*Brachionus capusuliflorus* PALLAS was misapplied)

The distribution of the present species is almost similar to the above (Fig. 2). It could not be found in any sample which was collected either from the Pacific coast district or from Kyûshû. The morphological aspects of this species are also given in the following section.

4. *Notholca striata* (O. F. MÜLLER, 1786)

5. *Notholca foliacea* (EHRENBERG, 1938)

6. *Notholca labis* (GOSSE, 1887)

7. *Notholca acuminata* (EHRENBERG, 1828)

These four *Notholca* species are well-known as hibernal elements and usually occur in the winter months in middle Japan. Though the number of the localities, where *Notholca acuminata* occurs are more numerous than those of *Notholca labis*, the frequencies of their occurrences are observed in a reverse order. *Notholca labis* generally occurs from January to March in the central district, but the duration of occurrence becomes from December to April in Nagano Prefecture, and moreover, it is detected even in July from the sample of Ozegahara (301). The seasonal succession of *N. foliacea* and *N. labis* will be given in a later section.

c. *Austral or warm-water species*

8. *Tetramastix opoliensis* ZACHARIAS var. *brevispina* AHLSTROM, 1932.

This is a species characteristic of warm eutrophic waters, and has been found in only two localities of the Central district, i. e., Akashi (535), and Soné-numa (504) which is a lagoon of Lake Biwa-ko.

9. *Pedalia mira* (HUDSON, 1871)

(Syn. *Hexarthra mira*)

The present species is of a warm-water stenothermal. Most specimens of *Pedalia mira*, which I have examined, were found in the samples collected in Lake Suwa-ko and the localities distributed southwestwards from there (Fig. 2). HADA (1937), however, reported this species from a small bog-pond at Tokotan, in eastern Hokkaidô (Fig. 2 - T), where the water temperature was above 20°C in summer. The writer also found it, though small in numbers, in a sample collected from Taté-nume (201), in the northernmost part of the main island of Japan, where the water temperature was 24.2°C at the end of August, 1953. In the southern part of Lake Biwa-ko (cf. Fig. 12), it always begins to occur in the middle of July, when the water temperature rises to 22°C; and thence increasing rapidly with the ascension of water temperature, it reaches its maximum abundance either in the end of July or in the beginning of August, when the water temperature becomes 28°—30°C. Its diminution in the fall is rapid, and it disappears when the water temperature descends below 20°C. Its disappearing period is generally between the end of September and the beginning of October. Accordingly, *Pedalia mira* inhabits chiefly the waters in the southern regions of Japan, but may occur in the northern parts, too, under the suitable conditions. A few individuals of it were found among the collections from Soné-numa (504) on October 27th, 1952, when the water temperature was 15.3—17°C. It seems to be a particular case that the individuals were left alive as the remainders of inhabitants in the preceding warmer season. The occurrence of *Tetramastix opoliensis* var. *brevispina* in Soné-numa is also nothing else than the similar case with the present species.

10. *Keratella valga* (EHRENBERG, 1834)

This species is closely related to *Keratella quadrata*, but the status of its distribution is quite contrary to the latter, in occurring in warm waters. It is distributed throughout the regions which neighbour to the south of the area where *Keratella quadrata* occurs (Fig. 2). It is needless to say that either altitudes or seasons influence upon its distribution as in the case of *K. quadrata*. It is worth to mention that *K. valga* is found in Nagano Prefecture where *K. quadrata* occurs commonly. The morphological variations of this species are so great that some considerations about them are given under another section.



Table 1. Localities and the number of samples

Locality		Number of samples	Locality		Number of samples
1. Hokkaidô:			2. North eastern District:		
			201	Mt. Hakôda	33
101	Ô-numa	2	(1 Aka-numa, 2 Kagami-numa, 3 Sairen-numa, 4 Tsuki-numa,		
102	Ko-numa	1	5 Hyôtsu-numa, 6 Ko-numa, 7 Aka-numa, 8 Toko-numa.)		
103	Junsai-numa	1	202	Tsuta-numa	1
104	Sapporo, Botanical Garden	2	203	Towada-ko	3
105	Chitosemura	1	204	Tanawa-ko	4
106	Tsuru-numa	1	205	Hiraisumi (Mouétsunji)	2
107	Hangatsu-ko	1	206	Shinai-numa	1
108	Tôya-ko	2	207	Nabire-numa	2
109	Kuttara-ko	1	208	Hibara-ko	2
110	Shikotsu-ko	2	209	Inawashiro-ko	1
111	Shikaribetsu-ko	1	210	Shimokita Peninsula	
112	Aken-ko	1	Ômasaki lake group		
113	Ryôshi-ko	1	Itako-numa of Fukushi lake group		
114	Tôro-ko	9	Higashitôri lake group		
		26	Others		
			3		
			69		

Locality		Number of samples	
3. Central mountainous districts:			
301 Oseghara	63	318	Yodamura 4
302 Chūsenji-ko	2	319	Shigen Heights 61
303 Yutawa	1		(1 Iobi-numa, 2 Maru-ike, 3 Biwa-ike, 4 Hara-ike, 5 Shikano-kolke, 6 Ueno-kolke, 7 Naga-ike, 8 Kiyama-ike, 9 Kido-ike, 10 Hyōtan-ike, 11 Shibu-ike, 12 Ōnuma-ike, 13 Moto-ike, 14 Shi-juhachi-ike, 15 Okama.)
304 Haru-numa	1		
305 Suge-numa	1		
306 Kōtoku-numa	1	320	Tenribara 1
307 Otashiro-ike	1	321	Kasino Tampo 1
308 Usagi-jima bog	1	322	Shirouma-Ōike 1
309 Kikuri-gm-ike near Komei Pass	1	323	Miyagawa-ike 1
310 Haruma-ko	1	324	Mt. Kiso-koma 3
311 Nojiri-ko	29	325	Mikatanomine 1
312 Ōrubono-ike near Nojiri	1	326	Tanakubo-ike 1
313 Ama-ike near Nojiri	1	327	Aoki-ko 29
314 Shino-ike on Mt. Ontake	2	328	Nakatsuna-ko 6
315 Ōnabōmi-ike	1	329	Kisaki-ko 16
316 A pond by the Togakushi Road	1	330	Sura-ko 25
317 Zankōji, Nagano City	1	331	Togodamura 2
		332	Pitago-ike 1

Locality	Number of samples	Locality	Number of samples
333 Ima-ike	1	4. Eastern Pacific coast district:	
334 Shirokosa-ike	1	401 Kita-ura	2
335 Kirigamine	20	402 Kasumiga-ura	7
(1 Kasaiga-ike, 2 an anonymous pond, 3 Hyōtan-ike, 4 Odoribano-ike,		403 Tega-numa	1
5 a pond between Kasaiga-ike and Yashisaga-ike, 6 Yashisaga-ike.)		404 Imba-numa	2
336 Matsubara Lake Group	14	405 Naga-numa	2
(1 Usuratori-ike, 2 Ima-ko, 3 Chō-ko, 4 Usugo-ike, 5 Oshidenoumi,		406 Tōkyō	5
6 Zuminoki-ike.)		(1. A pond in Tokyo University, 2. Botanical Garden,	
337 Kitasaki Hebi-ike	1	3. Shinobazuno-ike.)	
338 Minamisaki Hobii-ike	1	407 Tōkyō	2
339 Hittano-ike	1	(1. Okubo, 2. Suginami.)	
340 Fukamino-ike	2	408 Ashino-ko	3
341 Ponds in Higashi-Chikuma-gun	17	409 Kawaguchi-ko	3
(1 Kosakada, 2 Harashinden, 3 Hir-ida, 4 Haraguchi, 5 Kōzi,		410 Yamanaka-ko	1
6 Katsawa, 7 Hada-kamino-ike, 8 Hada-shimono-ike, 9 Saragubamba,		411 Chita Penninsula	15
10 Hishijō, 11 Oite, 12 Shōguma, 13 Chikatō, 14 Asatsutsui,		(1. Tarumi, 2. Miyake, 3. Shin-ike, 4. Yanagibake, 5. Hamachō,	
15 an anonymous pond, 16 Kurinada-ike, 17 Minamibora-ike.)		6. Girls School, 7. Kariyado Park, 8 Ono machi, 9. Middle School,	
		10. Tokoname.)	
		412 Tsu	3
			<hr/> 76

Locality	Number of samples	Locality	Number of samples
5. Central district:			
501 Tsuge	1	513 Omuro	1
502 Yogo-ko	3	514 Misoroga-ike	4
503 Yakumogahara	6	515 Nakara-ike	4
504 Lake Biwa-ko		516 Ariga-ike	19
Otsu	792	517 Kamigano Ko-ike	1
Imasu	14	518 Botanical Garden	1
Yakushiji	14	519 Ogurano-ike	3
Tsudaura	1	520 Tado	10
Sonf-numa	3	521 Hirakata	1
Kyoto:		522 Komojima	1
505 Hako-ike	1	523 Kowata-ike	1
506 Shukushi-ike	1	524 Uji	1
507 Watsukushi-ike	1	525 Onaku	1
508 Fukuji-ike	3	526 Daigo	3
509 Hiroawano-ike	6	527 Bokujisō	7
510 Bentenobishige-ike	4	528 Kōryama	6
511 Osawa-ike	4	529 Nishinoya	1
512 Hage-ike (Mt. Kinugasa)	1	530 Mandano-ike	1
		531 Arai-ike	1



Locality	Number of samples	Locality	Number of samples
532 Tadaoyama (Kōbe)	1	Kanagi lake group	2
533 Jidō	1	702 Akita City	4
534 Tamu	6	703 Niigata	1
535 Akashi	2	704 Takaoka	1
		705 Higurajima	2
	932		19
6. Southern Pacific coast district:			
601 Shiota (Wakayama)	1	8. Western Japan Sea coast district:	
602 Sakawa (Wakayama)	1	801 Ōhigata	1
603 Kōyasu	1	802 Kahokugata	1
604 Tsuyama	2	803 Inasagata	1
605 Okayama	1	804 Suigetani-ko	5
606 Yashima (Sanuki)	5	805 Tōgō-ike	6
607 Uwajima	3	806 Koyama-ike	6
608 Akihomura	4	807 Tanaga-ike	1
		808 Shimonoseki	1
	18		22
7. North-eastern Japan Sea coast district:			
701 Tsugaru Peninsula		9. Western district:	
Tateoka lake group	8	901 Chikuzen Ueki	1
Enogatate-ike	1	902 Yamashita-ike (Beppu)	3

Locality	Number of samples
903 Shidake-Ike (Oita)	2
904 Mobeoka	4
(1 Misubidani, 2 Nibidani, 3 Shiranashidani, 4 Shiashidani.)	
905 Miyasaki	2
906 Mt. Kirishima	4
(1 Mt-Ike, 2 Ko-Ike, 3 Fudô-Ike.)	
907 Kagoshima	2
908 Sumiyoshi-Ike	2
909 Iwakura	1
910 Unagi-Ike	10
911 Ikeda-ko	1
912 Kagami-Ike	1
913 Suwa-Ike (Shinobara Peninsula)	1
914 Unzen	3
(1 Ama-Ike, 2 Hirogawara-Ike, 3 Shirakumono-Ike.)	
	37
Total	1,523

Table 2. Taxonomic arrangement of the Phylum Rotatoria

Phylum Rotatoria	Order 5 Ploima
Class 1 Digenonta	Family Notommatidae (virgate or virgate-forcipate mastax)
Order 1 Sisoniida	Family Synchaetidae (virgate or virgate-forcipate mastax)
Order 2 Bdelloidea (ramate mastax)	Family Microcodonidae* (forcipate mastax)
Family Philodinidae	Family Ploesomatidae (virgate mastax)
Family * Habrotrichidae	Family Gastrypodidae (virgate mastax)
Family * Philodinavidae	Family Trichocercidae (virgate mastax)
Family * Adinetidae	Family Asplanchnidae (incudate mastax)
Class 2 Monogononta	Family Brachionidae (malleate mastax)
Order 3 Flosculariacea (malleoramate mastax)	
Family Flosculariidae	
Family Conochilidae	
Family Filiniidae	
Family Testudinellidae	
Family * Trochosphaeridae	
Order 4 Collothecacea (uncinate mastax)	
Family Collothecidae	

Order 1 consists of marine rotifers: The families marked with an asterisk \* are not yet found in Japanese inland waters.

Table 3. List of species found in Japanese inland waters

District	I	II	III	IV	V	VI	VII	VIII	IX	X
<b>Class 1 Digenonta</b>										
<b>Order Kallioidea</b>										
<b>Family Philodinidae</b>										
1. Botaria rotatoria (Pallas)	+	-	+	+	+	-	-	-	+	
2. Botaria neptunia (Skrenberg)	+	-	-	-	+	-	-	-	-	
3. Macrotrachea multipinosus Thompson	-	-	-	-	+	-	-	-	-	
4. Macrotrachea socialis (Kallioott)	-	-	+	-	-	-	-	-	-	
5. Philobia symbiotica (Zelinka)	-	-	-	-	+	-	-	-	-	
6. Diastirocha aculeata (Skrenberg)	+	+	+	-	+	+	-	-	-	
<b>Class 2 Monogononta</b>										
<b>Order Ploesulariacea</b>										
<b>Family Ploesulariidae</b>										
(1) Ploesularia ringens (Linnaeus)	-	-	-	-	-	-	-	-	-	*
6. Ploesularia jennus (Hudson)	+	-	-	-	-	-	-	-	-	
9. Isotimularia plosularia (O.F. Miller)	-	-	-	-	+	-	-	-	-	
<b>Family Comochilidae</b>										
10. Comochilus hippocrepis (Schrank)	+	+	+	+	+	-	-	-	-	+
<b>Family Piliinidae</b>										
11. Comochilus unicoloris Boussolet	+	+	+	+	+	+	+	+	+	+
12. Comochiloides natans (Jellico)	-	+	+	-	+	-	+	-	+	
13. Comochiloides comobasis Skorkov	-	-	-	-	+	-	-	-	-	+
14. Comochiloides doszurnatus (Hudson)	-	+	+	-	+	-	+	-	+	
<b>Family Piliinidae</b>										
15. Piliina cornuta (Weisse)	-	-	-	-	-	-	-	-	-	+
16. Piliina pasana (O.F. Miller)	-	-	-	-	-	-	-	-	-	
17. Piliina longicaeta (Skrenberg)	+	+	+	+	+	-	-	+	+	
18. Piliina longicaeta limetica (Zacharias)	-	-	-	-	+	-	-	+	-	
19. Piliina longicaeta terminalis (Plato)	+	+	+	-	-	-	-	-	-	
20. Tetrametrix opolienensis Zacharias	-	-	-	-	+	-	-	-	-	
21. Pedalia femina (Lewander)	-	-	-	+	-	-	-	-	+	
22. Pedalia mira (Hudson)	+	+	+	+	+	-	-	+	+	
<b>Family Testudinellidae</b>										
23. Testudinella bidentata (Fermits)	-	+	-	-	-	-	-	-	-	
24. Testudinella elliptica (Skrenberg)	-	+	-	-	-	-	-	-	-	
25. Testudinella patina (Hermann)	+	+	+	+	+	-	+	-	+	

District	I	II	III	IV	V	VI	VII	VIII	IX	+
26. <i>Testudinella brevicaudata</i> Yamamoto	-	-	-	-	+	-	-	-	-	-
27. <i>Testudinella brycei</i> Hanar	-	+	-	-	-	-	-	-	-	-
28. <i>Testudinella parva</i> (Ternits)	-	+	-	-	-	-	-	-	-	-
29. <i>Pompholyx complanata</i> Gosse	+	-	+	-	+	-	-	+	+	-
30. <i>Pompholyx sulcata</i> Hudson	-	-	-	+	-	-	+	+	-	-
Order Clolothecacea										
Family Collotheacidae										
31. <i>Collothea cornuta</i> (Dobie)	-	-	-	-	+	-	-	-	-	-
(32) <i>Collothea mutabilis</i> (Hudson)	-	-	-	-	+	-	-	-	-	-
Order Ploima										
Family Motomatidae										
(33) <i>Motomata aurita</i> (O.F.Miller)	-	-	-	-	-	-	-	-	-	+
(34) <i>Cephalodella ostellina</i> (O.F.Miller)	-	-	-	-	-	-	-	-	-	+
35. <i>Cephalodella forficula</i> Ehrenberg	-	+	-	-	-	-	-	-	-	-
36. <i>Monomata grandis</i> Tassin	+	+	-	-	-	-	-	-	-	-
37. <i>Monomata orbis</i> (O.F.Miller)	+	-	+	-	+	-	-	-	-	-
38. <i>Scaridium longicaudum</i> (O.F.Miller)	+	-	-	-	+	-	+	-	-	-
District	I	II	III	IV	V	VI	VII	VIII	IX	+
39. <i>Scaridium eudaetylotum</i> Gosse	+	-	-	-	-	-	-	-	-	-
(40) <i>Diaschisa eva</i> (Gosse)	-	-	-	-	+	-	-	-	-	-
(41) <i>Diaschisa erigma</i> Gosse	-	-	-	-	+	-	-	-	-	-
42. <i>Diaschisa gibba</i> (Ehrenberg)	-	-	+	-	+	-	-	-	-	-
43. <i>Diaschisa hoodi</i> Gosse	-	-	+	-	+	-	-	-	-	-
44. <i>Diaschisa tigridia</i> (Gosse)	-	-	+	-	-	-	-	-	-	-
Family Synchaetidae										
45. <i>Synchaeta oblonga</i> Ehrenberg	+	-	+	+	+	-	-	-	-	+
46. <i>Synchaeta pectinata</i> Ehrenberg	+	+	-	-	-	-	-	-	-	-
47. <i>Synchaeta stylata</i> Wierzejski	+	-	+	-	+	-	-	-	-	-
48. <i>Synchaeta vorax</i> Rousselet	-	-	-	-	-	-	-	-	-	+
49. <i>Synchaeta tremula</i> (O.F.Miller)	-	+	-	-	+	-	-	-	-	-
50. <i>Polyarthra euryptera</i> Wierzejski	-	+	+	-	+	-	+	-	+	+
51. <i>Polyarthra trigla</i> Ehrenberg	+	+	+	+	+	+	+	+	+	+
Family Ploesomatidae										
52. <i>Ploesoma hudsoni</i> (Imhof)	+	-	+	+	+	-	+	-	-	-
53. <i>Ploesoma triacanthum</i> (Bergendal)	-	+	+	-	-	-	-	-	-	-
54. <i>Ploesoma truncatum</i> (Lavander)	+	+	+	+	+	+	+	-	+	+



District	I	II	III	IV	V	VI	VII	VIII	IX	**
55. <i>Pleurota lenticularis</i> Herrick	-	-	-	+	*	-	-	-	-	-
Family Gastropodidae										
56. <i>Gastropus minor</i> (Housley)	-	-	+	-	*	+	-	-	-	-
57. <i>Chromogaster ovalis</i> (Berglund)	-	-	+	+	*	-	-	-	-	-
58. <i>Chromogaster testudo</i> Lasterborn	-	-	+	-	+	+	-	-	+	+
Family trichoceridae										
59. <i>Trichocerca tenuis</i> (Gosse)	-	-	+	-	+	-	-	-	-	-
60. <i>Trichocerca scipio</i> (Gosse)	-	+	+	-	+	-	-	-	-	-
61. <i>Trichocerca cylindrica</i> (Jahod)	-	+	+	+	+	+	-	-	+	+
62. <i>Trichocerca aspinosa</i> (Härsjö)	*	-	+	+	+	+	-	-	-	-
63. <i>Trichocerca longicosta</i> (Schmiedeknecht)	+	-	+	+	+	-	-	-	-	-
64. <i>Trichocerca cristata</i> Herring	-	-	+	+	+	-	-	-	-	-
65. <i>Trichocerca bicristata</i> (Gosse)	+	+	-	-	+	-	+	-	-	-
66. <i>Trichocerca elongata</i> (Gosse)	+	+	+	+	+	-	+	-	-	-
67. <i>Trichocerca stylata</i> (Gosse)	-	-	+	-	+	+	-	-	+	+
68. <i>Trichocerca pusilla</i> (Jennings)	*	-	+	-	+	-	-	-	-	-
69. <i>Trichocerca rufus</i> (O.F. Miller)	-	-	+	-	+	-	-	-	-	-
70. <i>Trichocerca</i> (Jennings) <i>trigata</i> (O.F. Miller)	+	+	+	+	+	-	+	-	-	-

District	I	II	III	IV	V	VI	VII	VIII	IX	**
71. <i>Trichocerca</i> (Jennings) <i>collaris</i> (Housley)	-	+	+	-	+	-	-	-	-	-
72. <i>Trichocerca</i> (Jennings) <i>tenuior</i> (Gosse)	+	+	+	-	+	-	-	-	-	-
73. <i>Trichocerca</i> (Jennings) <i>stylata</i> (Herring)	+	+	+	+	+	+	+	+	+	+
74. <i>Trichocerca</i> (Jennings) <i>insignis</i> (Herrick)	-	+	-	+	-	-	-	-	-	-
75. <i>Trichocerca</i> (Jennings) <i>porcellus</i> (Gosse)	-	-	+	-	+	-	+	+	-	-
76. <i>Trichocerca</i> (Jennings) <i>brachyura</i> (Gosse)	+	+	+	+	+	+	+	+	+	+
Family Asplanchnidae										
77. <i>Asplanchna herickii</i> de Geere	+	+	-	-	-	-	-	-	-	-
78. <i>Asplanchna priodonta</i> Gosse	+	+	+	+	+	+	+	+	+	+
79. <i>Asplanchna sieboldii</i> (Jagdis)	-	-	+	+	+	-	+	-	-	-
80. <i>Asplanchna brigitteae</i> Gosse	-	-	-	+	-	*	-	+	+	+
(81) <i>Asplanchna pyrix</i> (Ehrenberg)	-	-	-	-	-	-	+	-	-	-
Family Brachionidae										
82. <i>Brachionus falcatus</i> Zacharias	-	-	-	+	-	-	-	-	-	-
83. <i>Brachionus quadridentatus</i> Hermann	+	+	+	+	+	+	-	+	-	-
84. <i>Brachionus quadridentatus melnisi</i> Barrois et Dudy	-	+	-	-	+	+	-	-	-	-

District	I	II	III	IV	V	VI	VII	VIII	IX	X
85. <i>Brachionus quadridentatus</i> brevispinus Ehrenberg	+	-	+	-	-	-	-	-	-	-
86. <i>Brachionus quadridentatus</i> entzii France	+	+	+	-	-	-	+	-	-	-
87. <i>Brachionus quadridentatus</i> rhennanus Lauterborn	+	+	+	-	-	-	-	-	-	-
88. <i>Brachionus quadridentatus</i> cluniorbicularis Skorikov	+	+	+	-	-	-	-	-	-	-
89. <i>Brachionus plicatilis</i> O.F. Müller	-	-	+	-	-	-	-	+	-	-
90. <i>Brachionus leydigii</i> Cohn	-	-	+	-	-	-	-	-	-	-
91. <i>Brachionus rubens</i> Ehrenberg	-	+	-	-	-	-	-	-	-	-
92. <i>Brachionus ureolaris</i> O.F. Müller	+	-	+	+	+	+	-	-	-	-
93. <i>Brachionus angularis</i> Gosse	-	-	+	+	+	+	-	+	+	+
94. <i>Brachionus angularis</i> bidens Plate	-	-	-	+	+	+	-	-	-	-
95. <i>Brachionus angularis</i> cheilonis Ahlstrom	-	-	+	-	-	-	-	-	-	-
96. <i>Brachionus calyciflorus</i> Pallas	-	-	+	+	+	+	+	+	+	+
97. <i>Brachionus calyciflorus</i> asphiceros Ehrenberg	-	-	+	+	+	+	-	-	-	-
98. <i>Brachionus calyciflorus</i> aurasiiformis Brehm	-	-	+	+	+	+	-	-	-	-
District	I	II	III	IV	V	VI	VII	VIII	IX	X
99. <i>Brachionus calyciflorus</i> dorsus Gosse	-	-	-	+	-	+	-	+	-	-
100. <i>Brachionus calyciflorus</i> dorsus spinosus Wierzejcki	-	-	-	-	-	-	+	-	+	-
101. <i>Brachionus dimidiatus</i> (Eryce)	-	-	-	-	+	-	-	-	-	-
102. <i>Brachionus forficula</i> Wierzejcki	-	-	-	-	+	+	-	-	-	-
103. <i>Brachionus budapestinensis</i> Daday	-	-	+	+	-	+	-	+	-	+
104. <i>Brachionus diversicornis</i> (Daday)	*	-	+	-	+	-	-	-	-	-
105. <i>Platylas patulus</i> (O.F. Müller)	+	+	+	-	+	+	+	-	-	-
106. <i>Platylas quadricornis</i> (Ehrenberg)	+	-	+	-	+	+	-	-	-	-
107. <i>Keratella erciformis</i> (Thompson) eichwaldi (Lavander)	*	-	-	*	-	-	-	-	+	-
108. <i>Keratella oohlearis</i> (Gosse)	+	+	+	+	+	+	+	+	+	+
109. <i>Keratella oohlearis</i> tecta Gosse	+	+	+	+	+	+	+	+	+	+
110. <i>Keratella oohlearis</i> tecta micracantha Lauterborn	-	+	+	+	+	+	+	-	-	+
111. <i>Keratella oohlearis</i> macracantha Lauterborn	+	+	+	+	+	+	+	-	-	+
112. <i>Keratella oohlearis</i> irregularis Lauterborn	+	-	+	-	+	-	-	-	-	-

District	I	II	III	IV	V	VI	VII	VIII	IX	X
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113. <i>Kerria coccinea</i> <i>hirsuta</i> (Lamotte)	+	+	-	+	-	-	-	-	-	-
114. <i>Kerria javana</i> (Hawes)	-	-	-	-	+	-	-	-	-	-
115. <i>Kerria serrulata</i> (Muenberg)	+	-	-	-	-	-	-	-	-	-
116. <i>Kerria quadrata</i> (O.F. Miller)	+	+	+	+	+	+	+	+	+	+
117. <i>Kerria quadrata</i> <i>divergens</i> (Vot.)	+	-	+	-	+	-	-	-	-	-
118. <i>Kerria quadrata</i> <i>fruticosa</i> (Muenberg)	+	-	-	-	-	-	-	-	-	-
119. <i>Kerria quadrata</i> <i>testudo</i> (Muenberg)	-	+	-	-	-	+	+	+	+	+
120. <i>Kerria quadrata</i> <i>irregularis</i> (Jahns)	-	-	-	-	+	-	-	-	-	-
121. <i>Kerria velutina</i> (Muenberg)	-	-	-	-	+	+	+	+	+	+
122. <i>Kerria velutina</i> <i>asymetrica</i> <i>Barrois</i> et Dufay	-	-	-	-	-	-	-	-	-	-
123. <i>Kerria velutina</i> <i>monstrosa</i> <i>Barrois</i> et Dufay	-	+	+	+	+	+	+	+	+	+
124. <i>Kerria velutina</i> <i>tropica</i> (Apostol)	-	-	-	-	+	+	+	+	+	+
125. <i>Kerria velutina</i> <i>tropica</i> <i>asymetrica</i> <i>Apostol</i> <i>Barrois</i> et Dufay	-	-	-	-	+	-	-	+	+	+
(126). <i>Kerria velutina</i> <i>tropica</i> <i>monstrosa</i> <i>Apostol</i> <i>Barrois</i> et Dufay	-	-	-	-	-	-	-	-	-	+

District	I	II	III	IV	V	VI	VII	VIII	IX	X
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127. <i>Kerria longipennis</i> (Kellcott)	+	+	+	+	-	-	-	-	-	-
128. <i>Kerria serrulata</i> (O.F. Miller)	+	-	-	-	-	-	-	-	-	-
129. <i>Kerria foliolosa</i> (Muenberg)	-	-	-	-	+	-	-	-	-	-
130. <i>Kerria lutea</i> (Gosse)	-	-	+	+	+	+	+	+	+	+
131. <i>Kerria acuminata</i> (Muenberg)	+	-	+	+	+	+	+	+	+	+
132. <i>Kerria flava</i> (Gosse)	+	+	+	+	+	+	+	+	+	+
133. <i>Kerria serrulata</i> (O.F. Miller)	-	-	+	+	+	+	+	+	+	+
(134). <i>Kerria brasiliensis</i> (Muenberg)	-	-	-	-	+	-	-	-	-	-
135. <i>Kerria dilatata</i> (Muenberg)	+	+	+	+	+	+	+	+	+	+
136. <i>Kerria deflexa</i> (Gosse)	+	+	+	+	-	-	-	-	-	-
137. <i>Kerria triquetra</i> (Muenberg)	-	+	+	+	-	-	-	-	-	-
138. <i>Kerria propinqua</i> (Gosse)	-	-	-	-	+	-	-	-	-	-
139. <i>Kerria heterostyla</i> (Murray)	-	-	-	-	+	-	-	-	-	-
140. <i>Kerria eburnea</i> (Perry)	-	-	-	-	-	-	-	-	-	-
141. <i>Kerria amphitropis</i> (Harris)	-	-	-	-	+	-	-	-	-	-
142. <i>Kerria pterigoides</i> (Dunlop)	-	-	+	-	-	-	-	-	-	-
143. <i>Kerria latissima</i> (Hilgendorf) var. <i>americana</i> (Harris)	-	-	-	-	+	-	-	-	-	-

District	I	II	III	IV	V	VI	VII	VIII	IX	+
144. <i>Lepadella benjamini</i> Harring	-	-	-	-	+	-	-	-	-	-
145. <i>Lepadella infusata</i> Harring	-	-	-	-	+	-	-	-	-	-
146. <i>Lepadella acuminata</i> (Ehrenberg)	-	-	-	-	+	-	-	-	-	-
147. <i>Lepadella cryphaea</i> Harring	-	-	+	-	-	-	-	-	-	-
148. <i>Lepadella serrata</i> Yamamoto	-	-	+	-	-	-	-	-	-	-
149. <i>Lepadella ovalis</i> (O.P. Miller)	-	+	+	+	-	-	-	-	-	-
150. <i>Lepadella patella</i> (O.P. Miller)	-	+	+	-	-	-	-	-	-	-
151. <i>Lepadella triptera</i> Ehrenberg	-	+	-	-	-	-	-	-	-	-
152. <i>Lepadella triptera</i> elata Myers	-	-	-	-	+	-	-	-	-	-
153. <i>Lophocharis salpina</i> (Ehrenberg)	-	-	+	+	+	-	-	-	-	-
(154.) <i>Mytilina bicarinata</i> (Ferty)	-	-	-	-	-	-	-	-	-	-
155. <i>Mytilina mucronata</i> (O.P. Miller)	-	-	-	+	+	-	-	-	-	-
156. <i>Mytilina ventralis</i> (Ehrenberg)	+	+	+	+	+	+	+	+	+	+
157. <i>Mytilina brevispina</i> (Ehrenberg)	-	-	+	-	+	+	-	-	-	-
158. <i>Mytilina trirama</i> (Gosse)	-	-	-	+	-	-	-	-	-	-
159. <i>Trichotria truncata</i> (Whiteledge)	-	-	-	+	+	+	-	-	-	-
160. <i>Trichotria pocillum</i> (O.P. Miller)	-	+	-	-	-	-	-	-	-	-
161. <i>Trichotria tetractis</i> (Ehrenberg)	+	+	+	+	+	+	-	-	-	+

District	I	II	III	IV	V	VI	VII	VIII	IX	+
162. <i>Macrochaetus collinsi</i> (Gosse)	-	-	-	-	+	-	-	-	-	+
163. <i>Macrochaetus subquadratus</i> Ferty	-	-	-	-	+	-	-	-	-	-
164. <i>Colurella obtusa</i> (Gosse)	+	+	+	+	+	+	+	+	+	-
165. <i>Colurella adriatica</i> Ehrenberg	-	-	+	+	+	+	+	+	+	-
166. <i>Colurella bioupidata</i> (Ehrenberg)	-	+	+	+	+	+	+	+	+	-
167. <i>Colurella colurus</i> (Ehrenberg)	-	+	+	+	+	+	+	+	+	-
168. <i>Colurella tessellata</i> (Glascoott)	-	+	+	-	-	-	-	-	-	-
169. <i>Lecane scutenta</i> (Jakubaki)	-	-	-	-	+	-	-	-	-	-
170. <i>Lecane intrasinuata</i> (Olofson)	-	-	+	-	+	-	-	-	-	-
171. <i>Lecane mira</i> (Murray)	-	-	+	-	-	-	-	-	-	-
172. <i>Lecane satyrus</i> Harring et Myers	-	+	-	-	-	-	-	-	-	-
173. <i>Lecane gissensis</i> (Zokstein)	-	-	+	-	-	-	-	-	-	-
174. <i>Lecane curvicerata</i> Yamamoto	-	-	-	-	+	-	-	-	-	-
175. <i>Lecane haicilyeta</i> Harring et Myers	-	+	-	-	+	-	-	-	-	-
176. <i>Lecane leontina</i> (Turner)	-	-	+	-	+	-	-	-	-	-
177. <i>Lecane luna</i> (O.P. Miller)	+	+	+	+	+	+	+	+	+	+
178. <i>Lecane papuana</i> (Murray)	-	-	+	-	-	-	-	-	-	-
179. <i>Lecane flexilis</i> (Gosse)	-	-	+	-	+	-	-	-	-	-

District	I	II	III	IV	V	VI	VII	VIII	IX	**
180. <i>Leconte infula</i> Harring et Myers	-	+	-	-	-	-	-	-	-	-
181. <i>Leconte bequevialis</i> Yamamoto	-	-	-	-	-	-	+	-	-	-
182. <i>Leconte trilioha</i> Yamamoto	-	-	-	-	+	-	-	-	-	-
183. <i>Leconte overrigida</i> Albritton	-	-	-	-	+	-	-	-	-	-
184. <i>Leconte unguilata</i> (Goose)	-	-	-	-	+	-	-	-	-	-
185. <i>Leconte ludwigii</i> (Korotstein)	-	-	-	+	-	-	-	-	-	-
186. <i>Leconte kavanaughi</i> Yamamoto	-	-	-	-	+	-	-	-	-	-
187. <i>Leconte brachydactyla</i> (Sisurova)	-	+	-	-	-	-	-	-	-	-
188. <i>Leconte ligona</i> (Dunlop)	+	-	-	-	-	-	-	-	-	-
189. <i>Leconte luterborni</i> Hauer	-	-	+	-	-	-	-	-	-	-
190. <i>Leconte normmanni</i> (Threnberg)	-	-	+	-	-	-	-	-	-	-
191. <i>Leconte subtilis</i> Harring et Myers	-	-	-	-	+	-	-	-	-	-
192. <i>Leconte candida</i> Harring et Myers	-	-	-	-	+	-	-	-	-	-
193. <i>Leconte nana</i> (Kurray)	-	-	-	-	-	-	-	+	-	-
194. <i>Leconte nodosa</i> Hauer	-	+	-	-	+	-	-	-	-	-
195. <i>Leconte truncata</i> Yamamoto	-	-	+	-	-	-	-	-	-	-
196. <i>Leconte perlicia</i> Harring et Myers	-	+	-	-	-	-	-	-	-	-
197. <i>Leconte arcuola</i> Harring	-	+	-	-	-	-	-	-	-	-

District	I	II	III	IV	V	VI	VII	VIII	IX	**
198. <i>Leconte pupilla</i> Harring	-	+	-	-	-	-	-	-	-	-
199. <i>Leconte latissimata</i> Yamamoto	-	+	-	-	-	-	-	-	-	-
200. <i>Leconte osseus</i> Yamamoto	-	-	+	-	-	-	-	-	-	-
201. <i>Leconte unioi</i> Yamamoto	-	-	+	-	+	-	-	-	-	-
202. <i>Leconte agilis</i> (Byrce)	-	-	+	-	-	-	-	-	-	-
203. <i>Monostyla elachia</i> Harring et Myers	-	-	-	-	+	-	-	-	-	-
204. <i>Monostyla pygmaea</i> Delay	-	+	-	-	-	-	-	-	-	-
205. <i>Monostyla lunaris</i> (Threnberg)	+	+	+	+	+	-	-	+	-	-
206. <i>Monostyla crenata</i> Harring	+	+	+	+	+	-	-	-	-	-
207. <i>Monostyla stenroosi</i> Neisner	+	-	+	-	+	-	-	-	-	-
208. <i>Monostyla bulla</i> Goose	+	+	+	-	+	-	-	-	+	-
209. <i>Monostyla quadridentata</i> Threnberg	-	+	+	+	+	-	+	-	-	-
210. <i>Monostyla unguifata</i> Yudeev	-	-	-	-	+	-	-	-	-	-
211. <i>Monostyla hamata</i> Stokes	-	-	-	-	+	-	-	-	-	-
212. <i>Monostyla clostercera</i> Scharda	-	+	+	-	+	-	-	-	-	-
213. <i>Monostyla arcuata</i> Byrce	-	+	+	-	+	-	-	-	-	-
214. <i>Monostyla pyritiformis</i> Delay	-	+	-	+	-	-	-	-	-	-



District	I	II	III	IV	V	VI	VII	VIII	IX	**
215. <i>Monostyla scus</i> Harring	-	-	+	-	-	-	-	-	-	-
216. <i>Monostyla opias</i> Harring et Myers	-	-	-	-	-	+	-	-	-	-
Total	I	II	III	IV	V	VI	VII	VIII	IX	*
+	57	67	117	51	139	39	27	23	36	-
o	11	5	5	9	19	3	4	2	2	7
Total	68	72	122	60	158	42	31	25	38	7

Remarks: \* Records by other investigators.

\*\* Record in unknown district.

Table 4. Widely distributing rotifers in Japan

Species	Numbers of occur- ing localities	Distributing districts
<i>Keratella cochlearis</i> (incl. var. & formae)	155	9
<i>Polarthra triola</i>	70	9
<i>Asplanchna priodonta</i>	42	8
<i>Pleesanc truncatum</i>	33	8
<i>Bohlanis dilatata</i>	39	8
<i>Conochilus unicornis</i>	38	8
<i>Trichocerca (Diurella) stylata</i>	23	8
<i>Lecane luna</i>	21	8
<i>Mytilina ventralis</i>	12	8
<i>Brachionus angularis</i>	34	7
<i>Plinia longiseta</i>	32	7
<i>Testudinella patina</i>	19	7



11. *Brachionus calyciflorus* PALLAS, 1766

The present species is also one of the commonest species. It is, however, to be noted that the present study failed to detect it in the region north of 33°N (Fig. 2). This is quite a contrary status of the distribution to *Brachionus quadridentatus*, which usually occurs in the northern regions of Japan, as already noted.

12. *Brachionus falcatus* ZACHARIAS, 1898

13. *Brachionus forficula* WIERZEJSKI, 1891

Both of these two species are well-known as subtropicopolitan rotifers inhabiting alkaline waters.

14. *Brachionus budapestinensis* DADAY, 1885

This is also a subtropicopolitan species in alkaline waters, but in summer months it can be found in the waters as north as in Akita (702). Though the morphological variation is indistinct, the length, the curvature of anterior spines and the ornamentation of lorica are somewhat variable.

A tropicopolitan Brachionid rotifer, *Brachionus caudatus* APSTEIN has not yet been met with in our country.

d. Brackish water species

15. *Brachionus plicatilis* O. F. MÜLLER, 1786 (Fig. 5)

The present species is distributed widely in brackish or saline waters of Japan. The variation of its lorica in size as well as in shape seems to be tolerable to the nature of its habitats, but it is easily identified with the shape of four lobed mental edge.

TABLE V

*Dimensions of Brachionus plicatilis*

District	Kahoku-gata	Kahoku-gata	Tsu	Hegura-jima	Suigetsu-ko
Length of lorica ( $\mu$ )	280	260	230	170	150
Width of lorica ( $\mu$ )	200	200	155	136	100

The length of lorica measured by AHLSTROM (1940) was 125  $\mu$  — 315  $\mu$ .

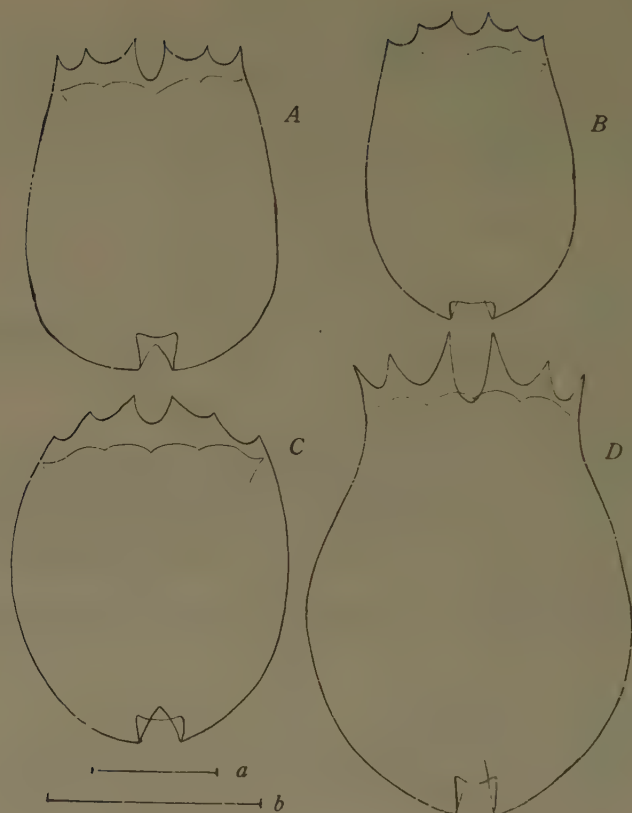


Fig. 5. *Brachionus plicatilis*

A: Kahoku-gata (704), B: Suigetsu-ko (707), C: Hegurajima (706), D: Tsu (412). Scales (100  $\mu$ ): a: A, b: B, C, D.

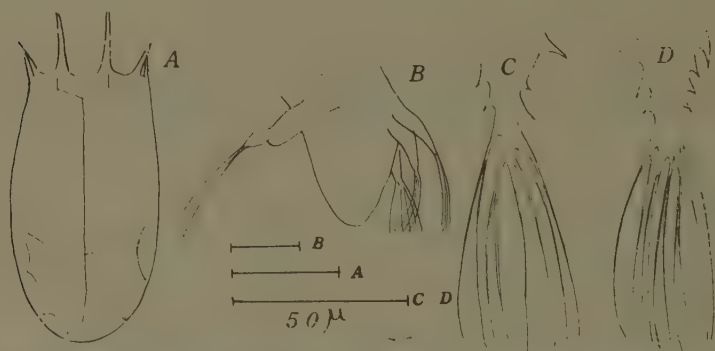


Fig. 6. A: *Keratella cruciformis eichwaldi* (Loc.: Kahoku-gata), B: *Pedalia fennica* (Loc.: Tsu), C: ditto (ventral appendage), D: ditto (dorsal appendage).

16. *Keratella cruciformis* (THOMPSON, 1892) var. *eichwaldi* (LEVANDER, 1894) (Fig. 6, a)

The present species is commonly found as a plankter in brackish water.

17. *Pedalia fennica* (LEVANDER, 1892) (Fig. 6, b, c, d)

This species occurs not only in brackish waters on the sea coast, but also in inland saline waters. It resembles closely *Pedalia mira* in general appearance, but lacks the apical processes which are prominent in the latter. The spines on both the dorsal and the ventral appendages are arranged in pair (Fig. 6, c, d).

In a paper on the rotatorian fauna of marine and brackish waters of Japan, HADA (1939) reported seven species in two groups. The first group, to which *Brachionus plicatilis*, *Brachionus angularis*, *Notholca striata* and *Notholca acuminata* belong, includes euryhaline rotifers which occur in marine, brackish and saline waters, and the other group comprises *Keratella cruciformis* var. *eichwaldi*, *Synchaeta vorax*, and *Synchaeta tavina*, all of which are stenohaline rotifers confined to brackish water. Among the four euryhaline species, the last three are commoner in freshwater than in brackish water.

Some rotifers other than the seven species mentioned above are found in brackish water. They are: *Keratella valga*, *Brachionus quadridentatus*, *Polyarthra trigla*, *Testudinella patina* and *Asplanchna* sp. and *Pedalia fennica*. These six species, except *P. fennica* which was an euryhaline rotifer, were collected in Lake Tôgô-ike (805). *Polyarthra trigla*, *Filinia longiseta* var. *limnetica* and *Brachionus calyciflorus* were found in Lake Suigetsu-ko (804); *Filinia cornuta* in Lake Kahoku-gate (802); *Brachionus calyciflorus* in an eel-culturing pond near the city of Tsu (412). All these lakes and ponds are of brackish water, in which the afore-mentioned rotifers were found always accompanied with one or two of haline species described in this section.

## B. Occurrence of the Rare Species

18. *Conochiloides coenobasis* SKORIKOV 1914 (Fig. 7, a)

SKORIKOV, Arb. ichtyol. Lab. Kaspi-Wolg. Fisch. Ver. Astrachan 3 (5): 30, figs. 1, 2, 1914.

AHLSTROM, J. Elisha Mitchell Sci. Soc. 54 (1): 94, figs. 7, 9, 1938.

This species is closely related to *Conochiloides natans* (SELIGO), but the ventral feelers rise from the mound-like expansion; the basal portion and the feelers are almost equal in length. The foot is short and almost entirely contracted when fixed. This is a very rare species and was found in Lake Sumiyoshi-like (908) in Kagoshima Prefecture. Recently, WATANABE (1954) reported it from a pond in Nara Prefecture.



19. *Brachionus angularis* var. *chelonis* AHLSTROM, 1940 (Fig. 7, b)  
AHLSTROM, Amer. Mus. Nat. Hist., Bull. 77, 155, figs 14, 15, 1940.

The lateral occipital spines are well-developed in size as long as the median ones. The dorsal lorica is ornamented with indistinct patterns of cuticular ridges. On either side of the foot opening there develops a short spine. The present species has been known only from several localities in the New World (New Orleans, La., Kinston, N.C., Acude Simao and Parahyba, Brazil); in Japan it was collected from Chikatô-ike (341), a pond in Nagano Prefecture. This variety is known as one of the smallest in the genus *Brachionus*.

20. *Lecane satyrus* HARRING & MYERS, 1926 (Fig. 7, c)

HARRING & MYERS, Trans. Wisc. Acad. 22, 362, Plate XXVII, figs, 3, 4, 1926.

This is one of the most interesting species of Rotatoria in its feature. HARRING & MYERS (1926) described that they had collected the present species at some localities in the United States (Glenburnie, near Baltimore, Maryland; Mount Desert Island; Maine; Mount Desert Island, Maine; Polk Country, Florida; around Atlantic City, New Jersey, and Vilas Country, Wisconsin). a single specimen was found in a collection from a pond, Hyôtan-ike (355), on Mt. Kirigamine, Nagano Prefecture.

21. *Lecane infula* HARRING & MYERS, 1926 (Fig. 7, d)

HARRING & MYERS, Ibid, 361, Plate XXVI, figs. 5, 6.,

The main patterns of surface markings on the dorsum consist of extraordinarily complicated dotted lines. This species was collected for the first time in small numbers in Lower Breakneck Ponk on Mount Desert Island, Mn, in the United States. In our country, it was found in the collections both from Hyôtan-ike (355) and from some bog ponds of Ozegahara (301).

22. *Lecane nodosa* HAUER, 1938 (Fig. 7, e)

HAUER, Arch. f. Hydrobiol. Suppl. 15, 520, fig. 42, 1938.

Several circular processes like pin-head are arranged on the dorsum. The contour of plate is very broadly rounded. This species had been reported nowhere since the description was first done by HAUER (1938) on the material from a pond in the Botanical Garden, Buitensorg (Bogor). In Japan, this species was found in a pond at Rokujizô, near Kyoto (523), and in Akagawa-numa, a small lake in the Shimokita Penninsula (201). The specimens obtained in Japan are considerably larger than that described by HAUER, as will be known from the following data of the dimensions.

TABLE VI.

*Dimensions of Lecane nodosa*

District	Java	Rokujizô	Akagawa-numa
Total length	87 $\mu$	—	—
Length of lorica	70 $\mu$	95 $\mu$	98 $\mu$
Length of dorsal plate	60 $\mu$	80 $\mu$	83 $\mu$
Bredth of dorsal plate	67 $\mu$	86 $\mu$	91 $\mu$
Bredth of ventral plate	53 $\mu$	72 $\mu$	—
Bredth of anterior margin	58 $\mu$	74 $\mu$	66 $\mu$
Length of toe	23 $\mu$	30 $\mu$	34 $\mu$

The present species has a close affinity with both *Lecane horne-manni* and *Lecane nana*.

23. *Lepadella pterygoida* (DUNLOP, 1897) (Figs. 7, f, g)

DUNLOP, J. Quekett Micr. Club, ser. 2, 6, 325, Plate 17.

The individuals collected in a *Sphagnum*-bog of Ozegahara (201) are different from the typical form in the feature which the wing-like lateral expansions are lacking. The typical form was collected from Shibu-ike, a pond on the Shiga Heights (319). It is cosmopolitan, but rare in Japan at the present step of study.

24. *Testudinella brycei* HAUER, 1938 (Fig. 7, h)

HAUER, Arch. f. Hydrobiol. Suppl., 15, 558, fig. 81, 1938.

This species was described by HAUER on the basis of two different materials, i.e., the specimens which were collected from a moor-pond in the Toba district of Sumatra, where there was investigated by the German Limnological Sunda-Expedition, and the other was the sketch of a *Testudinella* obtained from Scotland, which had been sent by Mr. BRYCE to him. The Toba district is about 1500 metres above sea level and the moor-pond was filled with water of pH 5.5. In Japan it was found in Akagawa-numa (201). The size of this speci-

TABLE VII

*Dimensions of Testudinella brycei*

District	Sumatra	Japan
Length of lorica	85 $\mu$	95 $\mu$
Width of lorica	58 $\mu$	73 $\mu$

men is slightly larger than that from Sumatra, as will be known from the following data.

25. *Testudinella bidentata* (TERNITZ, 1892) (Fig. 7, i)

The present species was found in the collection which containen *T. brycei*. It is an ubiquitous rotifer, but this is the second record ik Japan, since Prof. KAWAMURA had illustrated it in his text-book (1917), based upon a specimen taken in a pond in the Botanical Garden, Tokyo Imperial University.

26. *Keratella javana* (HAUER, 1938) (Fig. 7, j)

HAUER, Archiv f. Hydrobiol. Suppl., 15, 382, fig. 29. 1938.

AHLSTROM, Bull. Amer. Mus. Nat. Hist., 80, 434, 1943.

The present species was first described by HAUER (1938) from Java as a variety *javana* of *Keretalla cochlearis*; it was collected by the German Limnological Sunda-Espedition. Its habitat was a pond, Telega Pengilon, which was situated in the moorland in the Dieng high plain at an elevation of 2000 metres. A new combination, *Keratella javana* was later given by AHLSTROM (1943). In Japan, this species was found in a pond among the *Sphagnum*-bogs in Yakumogahara plain (about 900 metres above sea level) on Mt. Hira, Shiga Prefecture (503). The dimensions are was follows:

TABLE VIII.

*Dimensions of Keratella javana*

District	Java	Japan
Total length	—	139 $\mu$
Length of hind spine	67 $\mu$	16 $\mu$
Length of lorica proper	168 $\mu$	96 $\mu$

The Japanese specimens are much smaller in size than those from Java. The ratio of the hind spine to the body length calculated on the Japanese specimens is also very small.

Since the first description was made, the present species has been sporadically collected from several localities south of the equator. According to BERZINS (1952), who reported this species from West Australia based on the samples obtained by "Professor GISLEN's Expedition to Australia in 1951—1952", it is known also from New Zealand (RUSSEL 1950, 1952). GILLARD (1952) reported this species

from Katanga\*, Congo. The water from which those specimens had been collected showed an acid character (the pH values ranged from 4.0 to 5.5). The pH values of the water in Yakumogahara showed 5.4—5.8, and the water temperatures were from 15° to 22°C. Since 1947, a considerable number of individuals of the present species have been collected by the writer and some other investigators in the same locality every summer. The distribution area spreads out to the northern hemisphere over the equator.

As will be discussed later, the plankton rotifers have so wide ranges of distribution that most of them are commonly found in Japan with the exception of a few species. *Conochiloides coenobasis*, *Brachionus angularis* var. *chelonis*, *Keratella javana* are such examples. The common plankton rotifers are, however, particularly interesting for the comparative study of their morphological variations, seasonal changes, distribution problem, and so on, as will be discussed in the later sections.

### 3. MORPHOLOGICAL VARIATIONS

Some of the rotatorian species show more or less variabilities either in size or in form, owing to the cyclomorphosis in some cases and to the only environmental conditions in other cases. When every variant can be arranged continuously, all the members may be included in a single species, even if the range of variations is not narrow. It is, however, convenient to give a different name for each type. Some species belonging to the genera *Brachionus* and *Keratella* show particularly ample morphological variations.

1. *Brachionus calyciflorus* PALLAS (Fig. 8)

Many types of the present species are observed, but it is difficult to set sharp boundaries between them. Their representative types observed in Japan are enlisted below; sometimes variety or form names are adopted for each type.

- 1. Median occipital spines slightly longer than lateral ones, posterior spine absent ..... typical-type.
- 2. Median occipital spines slightly longer than lateral ones, posterior spines very long ..... *amphiceros*-type.
- 3. Median occipital spines same as above, posterior spines short ..... *anuraeiformis*-type.
- 4. Median occipital spines much longer than lateral ones, posterior spines absent ..... *dorcas*-type.

\* Dembo-river to Mafunda Dembo (3), 27/4/51 to 10  $\mu$   
Helder, snelstromend water, veel waterplanten, zandachtige bodem.  
Water system: Kasai. Luchttemperatuur: 28°C;  
Watertemperatuur: 23°C; pH: 5.5.

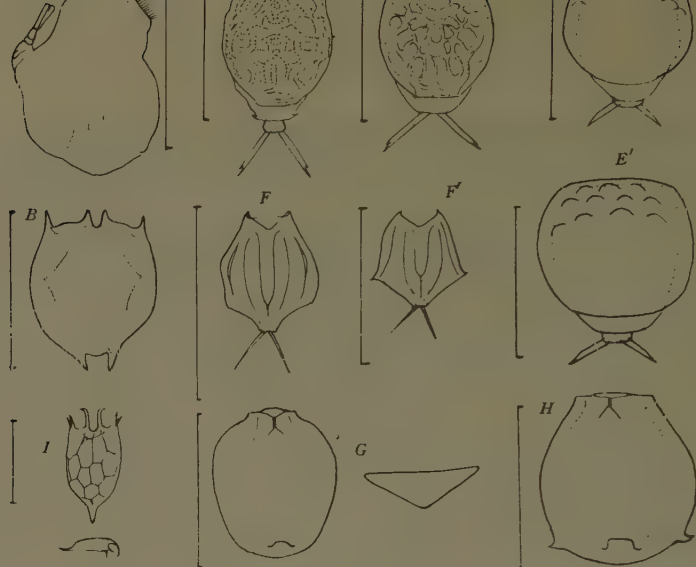


Fig. 7. A: *Conochiloides coenobasis*, B: *Brachionus angularis chelonis*, C: *Lecane satyrus*, D: *Lecane infula*, E, E': *Lecane nodosa*, F, F': *Lepadella pterygoida*, G: *Testudinella brycei* and its cross section, H: *Testudinella bidentata*, I: *Keratella javana* and its longitudinal section. Each scale: 100  $\mu$ .

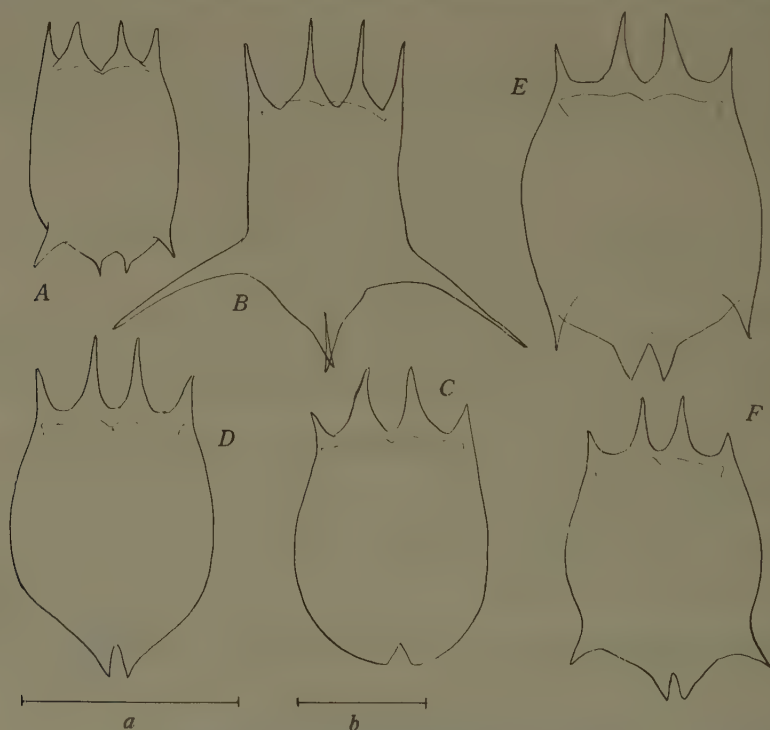


Fig. 8. *Brachionus calyciflorus*

A: (from Korea), B: Kirigamine (335), C: Tokyo (407), D: Yashima (606), E: Yashima (606), F: Tokyo (407). Scales (100  $\mu$ ): a: B, D, E; b: A, C, F.



5. Median occipital spines same as above, posterior spines one or two pairs ..... *dorcas-spinosus*-type.

According to the status of distribution of this species in Japan, those which belong to the types „*dorcas*” seem to be austral or warm-water rotifers. The remaining types are distributed widely in various districts except the northern and north-eastern districts.

## 2. *Brachionus quadridentatus* HERMANN (Fig. 9)

The median pair of occipital spines are the longest and outcurved considerably. The characteristics of various types are as follows:

1. Posterior spines about one half or three quarters of body length, not so divergent ..... typical-type.
2. Posterior spines very long and divergent ..... *melheni*-type.
3. Posterior spines about 1/8 to 1/3 length of body, somewhat divergent ..... *brevispinus*-type.
4. Posterior spines almost rudimentary ..... *entzii*-type.
5. Posterior corners almost rectangular ..... *rhenanus*-type.
6. Posterior corners rounded ..... *cluniorbicularis*-type.
7. Intermediate type between typical and *melheni*-types; between *entzii*-and *rhenanus*-types: between *rhenanus*-and *cluniorbicularis*-types, etc.

The typical type of the present species is distributed widely in Japan except the Kyûshû district. The *melheni*-type occurs chiefly in the Central district. The other types are distributed generally, as boreal forms, in the region north of the central mountainous district.

## 3. *Keratella quadrata* (O. F. MÜLLER) (Fig. 10, a-f)

With or without one or two posterior spines. The lorica is wider in the posterior width than in the anterior portion. The length of posterior spines varies greatly, from nearly as long as the body proper to entirely lacking. Various types of the species found in Japan are as follows:

1. Posterior spines about 1/2 of body length, both spines almost equal in length and in parallel direction each other; both reticulate and punctate patterns well-developed on dorsum ..... typical-type.
2. Posterior spines long, more than 1/2 of body length, strongly divergent, both reticulate and punctate patterns well-developed on dorsum ..... *divergens*-type.
3. Posterior spines long, more than 1/2 of body length, nearly equal in length, almost parallel, slightly incurved; dorsal patterns not distinct ..... *frenzeli*-type.
4. Posterior spines short, divergent slightly ..... *testudo*-type.
5. Right posterior spine well-developed, left one rudimentary ..... *irregularis*-type.

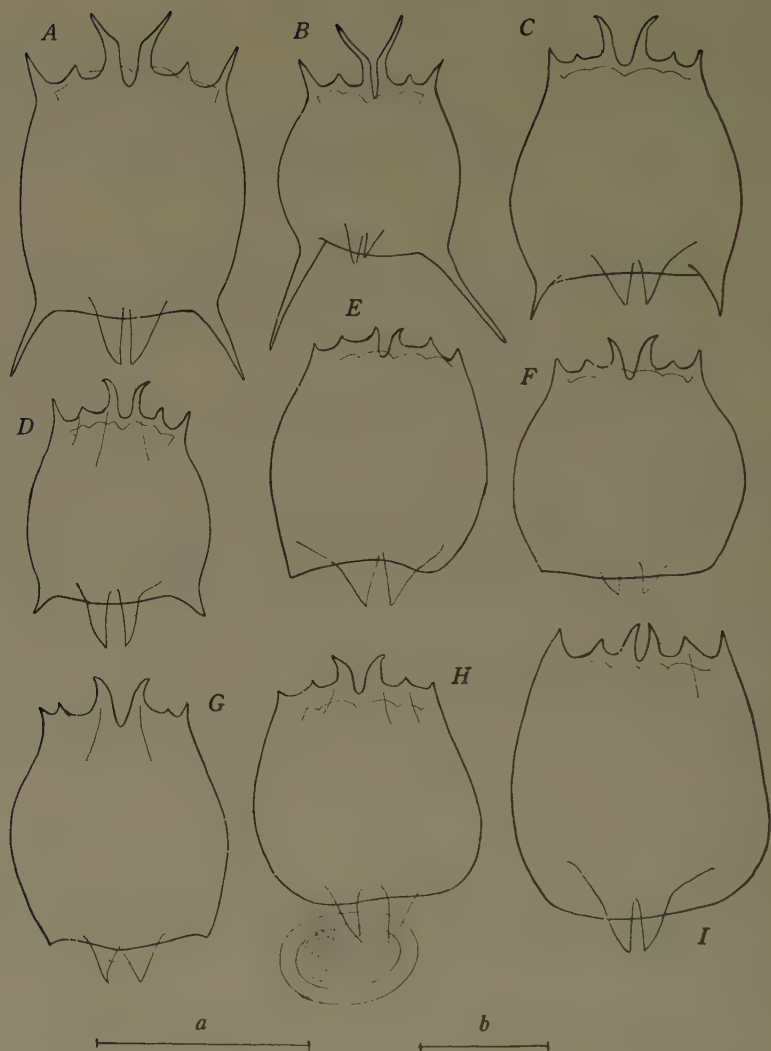


Fig. 9. *Brachionus quadridentatus*

A: Chô-ko (336), B: Shinai-numa (206), C: Yodamura (318), D: Ômazaki (210), E: Biwa-ko (504), F: Yodamura (318), G: Ômazaki (210), H. Momoyama (522), I: Tsu (412). Scales (100  $\mu$ ): a: A, I; b: B, C, D, E, F, G, H.

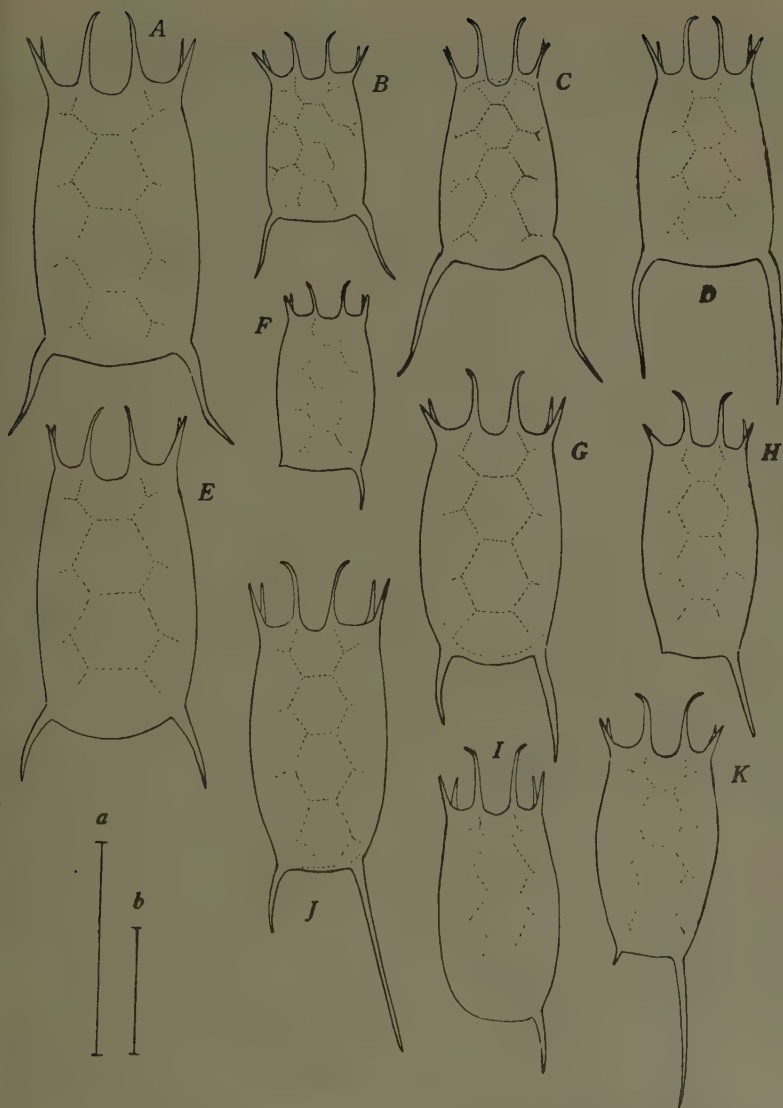


Fig. 10. A—F: *Keratella quadrata*, G—K: *Keratella valga*.

A: Typical form (Maru-ike 319), B: an intermediate form between the typical form and *divergens*-type (Shikotsu-ko 110), C: *divergens*-type (Suwa-ko 330), D: *frenzeli*-type (Akan-ko 102), E: *testudo*-type (Niigata 701), F: *irregularis*-type (Ogurano-ike 519); G: Typical form (Suigetsu-ko 707), H: *asymmetrica*-type (Tôgô-ike 708), I: *monstrosa*-type (Tôgô-ike 708), J: *tropica*-type (Kôriyama 528), K: *tropica-asymmetrica*-type (Akihomura 608).

Scales (100  $\mu$ ): a: A, E, G, H, I, J, K. b: B, C, D, F.

6. Intermediate type between typical and *divergens*-type.

7. Intermediate type between typical and *testudo*-type.

The typical type is the commonest. The *frenzelii* type occurs only in the northern district. In Nagano Prefecture, there occur numerous types.

#### 4. *Keratella valga* (EHRENBERG) (Fig. 10, g-k)

The width of body proper is greater at the anterior end than at the posterior end. The posterior spines are unequal in length; the left is shorter than the right. Sometimes, the left spine is absent, even if the right one is well-developed; both spines are absent in some cases. Both reticulate and punctate patterns on the dorsum are fundamentally similar to those of *K. quadrata*. Various lengths of posterior spines have been observed by many investigators for the taxonomic purposes. In this respect, EDMONDSON & HUTCHINSON (1934) described various varieties and forms of this species. AHLSTROM (1943) who did not distinguish various forms for the present species on the basis of only the length of posterior spines, gave two groups of variants in the feature of typical patterns on the dorsum, and concluded that it was divisible to two definite forma names, f. *tropica* and f. *brehmi*. The variants found in Japan belong to AHLSTROM's f. *tropica*, which may be identical with the following six forms offered by EDMONDSON & HUTCHINSON.

1. Posterior spines developed, left spine about 1/4, right spine about 1/3 of body length ..... typical-type.

2. Right posterior spine about 1/2 of body length, left one very short ..... *asymmetrica*-type.

3. Right posterior spine about 6/7, left one 2/5 of body length ..... *tropica*-type.

4. Right posterior spine about 3/5 of body length, left one lacking ..... *monstrosa*-type.

5. Right posterior spine long, left one very short ..... *tropica-asymmetrica*-type...

6. Right posterior spine long, left one lacking ..... *tropica-monstrosa*-type...

#### 5. *Keratella cochlearis* (GOSSE) (Fig. 11)

The present species is not only one of the commonest rotifers (Table IV), but also one of the most variable in shape. Having decided the variations on the basis of fundamental patterns on the dorsum and the size of hind spine, LAUTERBORN (1898, 1900) described five series of variants belonging to the present species. According to AHLSTROM (1943), LAUTERBORN's five series mentioned above are to be as follows:

1. The *macracantha* series belongs to the typical *K. cochlearis*. In the specimens of the United States, the median line on the dorsum has a slight jog on the right-side at a point between the first and the second plaques, while the median line is straight in most cases of European specimens. Both types are also found in Japan.

2. A new combination of names was proposed by AHLSTROM to the typical form of the *irregularis* series which should be a species separate from the present species. This is seldom seen in Japan.

3. The *robusta* series is a large-sized group, in which the median line does not jog. This type is rare in Japan.

4. The variety *hispida*, too, is larger in size; the whole surface of lorica is hispid, and sometimes the fundamental patterns of dorsum are indistinct. This is rarely met with in Japan.

5. The forma *leptacantha* LAUTERBORN was considered by AHLSTROM to be a local variant of the typical *K. cochlearis*.

Besides those mentioned above, there have been reported some other varieties which have not yet been found in Japan.

As already described, *Keratella cochlearis* is one of the commonest rotifers in Japan. The size of body proper varies considerably, the length of hind spine deviating from nothing to as long as or more than the body proper. It will be realized that variations seem to be caused not only by the conditions of localities but also by the seasonal factors. Generally speaking longspined individuals occur in early season and the progress of generations through repeated parthenogenesis makes the reduction of the length of hind spine. The cyclo-morphosis may, however, not occur due to the conditions of habitat water; an acyclic generation is resulted. A good example of such an acyclus due to a large body of water is seen in *K. cochlearis* in the southern basin of Lake Biwa-ko. The length of hind spines and the hind spine indices do not vary in accordance with the climates.

In North America, a small-sized *K. cochlearis* is said to occur in weakly acid water. On the contrary, a remarkably large type of *K. cochlearis* is found in the waters of similar condition in Japan, e. g., ponds among the *Sphagnum*-moors on the Shiga Heights (319) and on Mt. Hakkôda (201). The size of individuals from the Shiga Heights exceeds that of var. *robusta*, but they belong without doubt morphologically to the *macracantha* series. Moreover, it is a particular interest that the length of the hind spine is considerably longer than the body proper. It would, therefore, be called as the *megacantha* type in the *macracantha* series. The measurements made on more than one thousand individuals of this series revealed us the following facts worthy to be described.

A gap is clearly observed between the *megacantha* type and the *macracantha* type, and also between the *macracantha* type and the



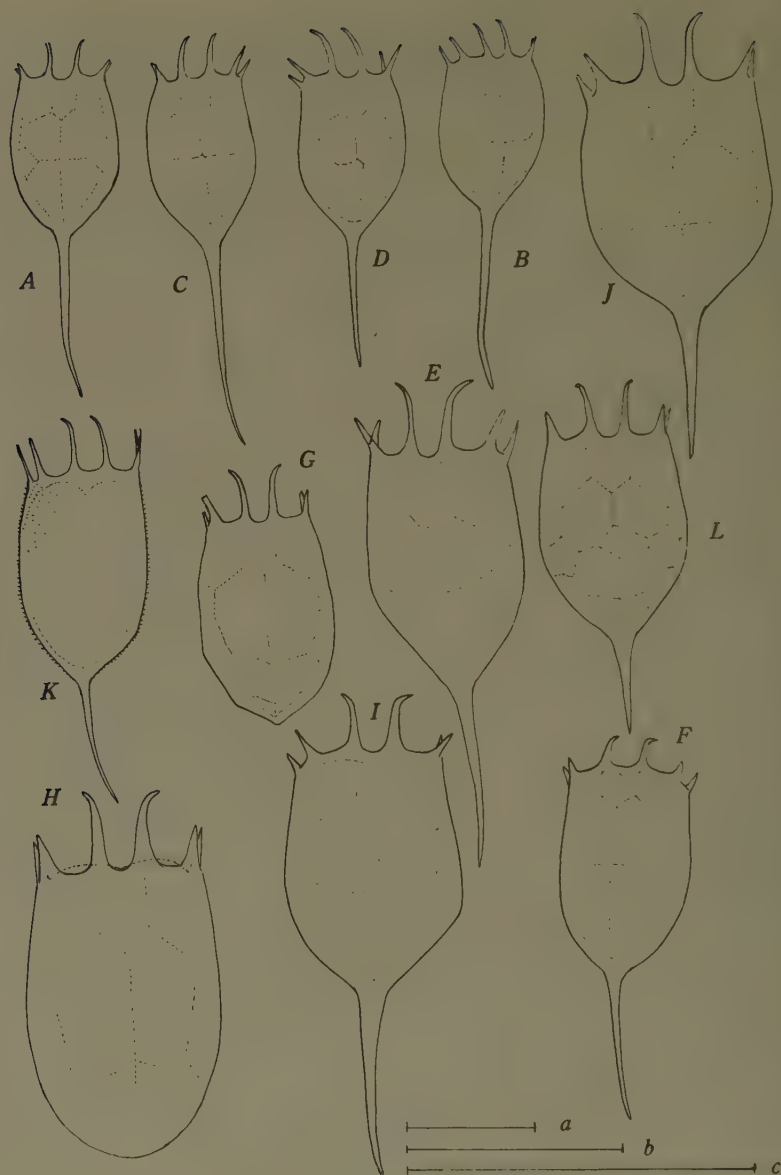


Fig. 11. *Keratella cochlearis*

A, B: Shiga Heights (319), C, D: Hakkôda (201), E: Oze-numa (301), F: Kizaki-ko (329), G: Kôriyama (528), H: Ko-ike (517), I: *robusta*, Haruna-ko (310), J: *robusta*, Chûzenji-ko (302), K: *hispida*, O-numa (101), L: *irregularis*, Tôya-ko (108). Scales (100  $\mu$ ): a: A, B, C, D; b: E, F, G, I, J, K, L; c: H.

*tecta* type, in the latter of which the hind spine is entirely lacking. On the other hand, individuals of intermediate types are continuous in regard to the features which are measured, either the length of body proper and hind spine or the hind spine indices. Anyhow, there can be seen a tendency that the larger the body size, the longer the hind spine.

The other forms of *Keratella cochlearis* are not common in Japan, so far as the present study has gone. Such forms occur chiefly in the northern districts; i. e., var. *irregularis* was found in Lake Tôya-ko of Hokkaidô (108) and Lake Nojiri-ko in the central mountainous district (311); var. *hispida* from Lakes Ô-numa (101) and Tôro-ko of Hokkaidô (114), Lakes Itakonuma (210) and Benten-ike (341); and var. *robusta* from Lakes Chuzenju-ko (302) and Haruna-ko (310).

#### 4. THE ANNUAL SUCCESSION OF PLANKTON ROTIFERS IN THE SOUTHERN BASIN OF LAKE BIWA-KO

The plankton samplings had been carried out regularly on Lake Biwa-ko off the Otsu Hydrobiological Station since its foundation in 1914. Having examined those samples obtained particularly during the years 1917-27, the writer identified as many as 75 species of rotifers. The common plankton rotifers were observed to be comparatively small in the number of species. Nevertheless, the species belonging to the eulimnoplankters were dominant or subdominant quantitatively.

The average annual changes of the common plankton rotifers examined during the present investigation are summarized in a diagram (Fig. 12), together with the curve of mean water temperatures. The figures are not based upon the absolute individual numbers, but upon the relative abundance of each species, because the samplings had not been carried out for the purpose of quantitative studies. The diagrams will, however, be sufficient to compare each other, each configuration of the diagram probably showing the fate of the species throughout the year.

1. *Polyarthra trigla*. This species occurs abundantly throughout the year, its maximum being observed in the beginning of May and its submaximum in the beginning of October. According to MORI (1945), this species outbreaks twice a year, the one in April and the other in September (bicyclic, perennal). His finding is nearly similar to the present result.

2. *Conochilus unicornis*. This species occurs in the middle of April; then increases rapidly, reaching its maximum population in the end of May. It decreases quite slowly, sometimes showing a

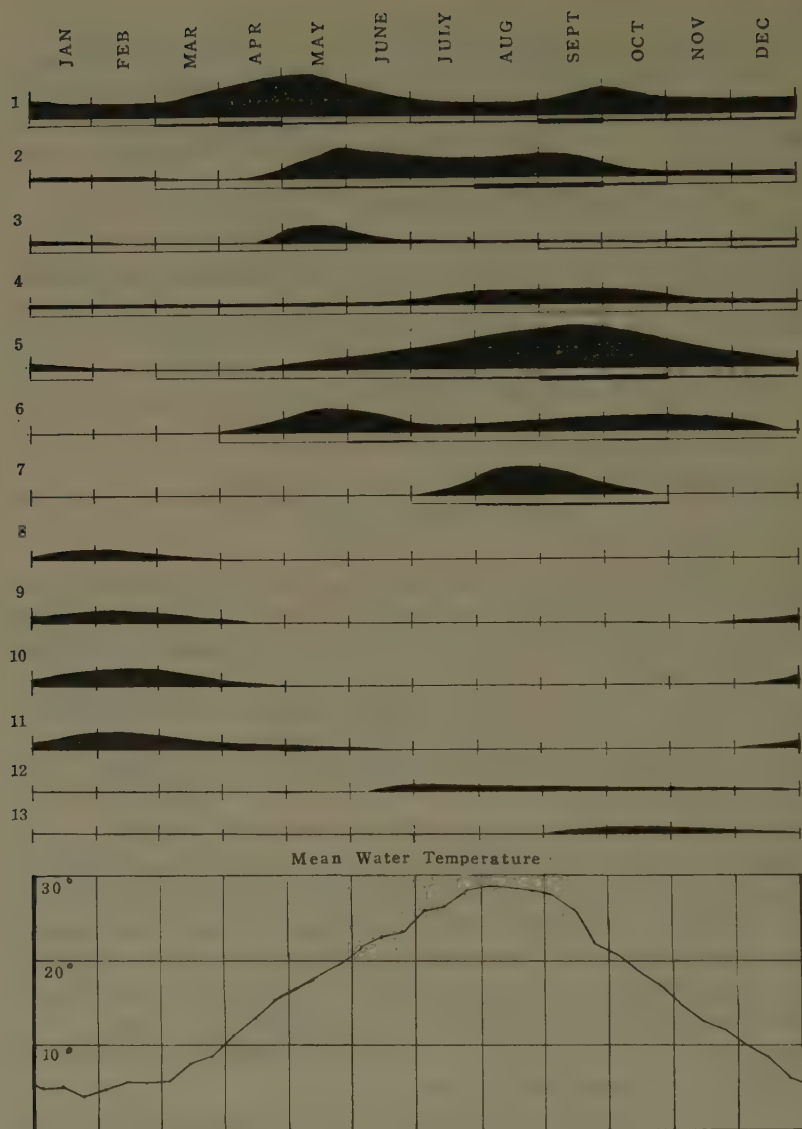


Fig. 12. Average annual changes of the relative quantities of several important plankton rotifers in the southern basin of Lake Biwa-ko.

1: *Polyarthra trigla*, 2: *Conochilus unicornis*, 3: *Asplanchna priodonta*, 4: *Testudinella patina*, 5: *Keratella cochlearis*, 6: *Ploesoma truncatum*, 7: *Pedalia mira*, 8: *Notholca labis*, 9: *Notholca foliacea*, 10: *Trichotria pocillum*, 11: *Trichotria tetractis*, 12: *Chromogaster testudo*, 13: *Pompholyx complanata*.

slight inclination of increase in August, and then getting a faint submaximum in the beginning of September. After this time, it decreases suddenly and diminishes in the middle of March in the next year. It is possible to see the present species for almost whole the year excepting merely a short period in the early spring (monocyclic, summer form).

3. *Asplanchna priodonta*. This species begins to occur in the end of April and gets its maximum in the middle of May, then decreasing suddenly. But, they are found in a small number during the months from June to January. It is considered as a dicyclic which increases either in spring or in summer, though sometimes monocyclic. The case observed is the latter (monocyclic, early summer).

4. *Testudinella patina*. This species is originally a bottom dweller, but is often seen as a plankter for its easily floatable shape. It occurs in a small number throughout the year, but is rather numerous seen in the period between the middle of July and the middle of October (noncyclic).

5. *Keratella cochlearis*. The dominant type of the present species in this area seems to be the *macracantha* type. It occurs in the middle of April, then increasing gradually to the maximum in the middle of September; it decreases gradually to the diminution in the middle of February (monocyclic, autumnal).

6. *Ploesoma truncatum*. This species occurs in April, getting its maximum in the middle of May and then decreases gradually; it slightly increases again from the end of August, showing a rather slight submaximum peak in the end of October, and then diminishes in December (dicyclic, aestival and autumnal).

7. *Pedalia mira*. As already described in the second section of the present chapter, this species is a typically aestival rotifer. Its occurrence in this area is confined to the months between the middle of July and the middle of October (monocyclic, aestival).

8. *Notholca labis*, 9. *Notholca foliacea*, 10. *Trichotria pocillum*, 11. *Trichotria tetractis*. These four species are hibernal elements. The duration of occurrence of the first-named species is the shortest and that of the last-named is the longest.

12. *Chromogaster testudo*. Its occurrence is not conspicuous; its maximum period is seen in the beginning of June. It was not collected in some years.

13. *Pompholyx complanata*. Similar to the above species, seen in a small number. The duration of occurrence is shorter than that of the above species.

14. *Euchlanis dilatata*. This species is found throughout the year, but the mode of occurrence is so irregular that it is difficult to draw the curve in the figure.

15. *Synchaeta* spp. At least three species belonging to this genus, i. e., *S. oblonga*, *S. stylata*, and *S. tremula*, are observed in considerable numbers. Their abundance is particularly tolerable to habitat conditions in both winter and spring, probably due to the occurrence of *S. oblonga*. The autumnal abundance, however, seems to be caused chiefly by a considerable presence of *S. stylata*. It is, however, difficult to determine them to species in the preserved specimens, so that it is impossible to figure the annual change of each species.

The important components of the rotatorian plankton in this region of Lake Biwa-ko are *Polyarthra trigla*, *Conochilus unicornis*, and *Keratella cochlearis*. Although *Synchaeta* spp. are collected in a pretty large quantity, it is better to exclude them from the argument, because of the confusion of species. There are two more additional components; *Pedalia mira* in summer and *Ploesoma truncatum* in both spring and autumn. In winter, the aforementioned three important elements have become scanty, their place having been replaced by hibernal elements, though not large quantitatively. Consequently, in the southern basin of Lake Biwa-ko, the warm season may be preferable to these rotifers rather than the cold season. Their annual successions observed in the course of the present study essentially resemble those which were observed by NEGORO (1954) on the plankton of the main basin of the same lake. MORI's observations (1945) at the southern part of the lake during 1934—1937 are also consistent with the present results, with a few exceptions.

## 5. DISCUSSION: THE ROTIFER FAUNA OF JAPAN; ITS COMPOSITION AND DERIVATION

The rotatorian fauna of Japanese inland waters consists of those species which belong to some categories, as stated in the second chapter. The widely distributed species are dominant in every district i. e., the rate of the ubiquitous species shows 60—86 % in any district. Some rotifers endemic to any district are also observed, and such species are detected in somewhat large percentage in the third and fifth districts. It may be due to frequent samplings and to the dense localities in these two districts. Not a few number of temporal plankton rotifers are observed in accompanying with the eulimnoplankters; consequently, the majority of such endemic species belonging to the important genera are creeping rotifers, as will be seen in the following table.

It is interesting that the closely allied genera *Lecane* and *Monostyla* are quite different in the way of their distribution. *Lecane luna* is the only ubiquitous species in the genus and the remainders are un-



common, while most species of the genus *Monostyla* are distributed in considerably divergent localities. Of 9 rare species in the second section of the Second Chapter, 6 were temporal plankters. All of the 10 new species, which were described by the present writer from Japan (*Testudinella brevicaudata*, *Lepadella serrata*, *Lecane curvicerata*, *Lecane hegurensis*, *Lecane triloba*, *Lecane kawamurai*, *Lecane latissima*, *Lecane truncata*, *Lecane uénoi*, *Lecane ozensis*), belong to the creeping forms, of which 8 species are included in the genus *Lecane*.

TABLE IX  
*Endemic species of the five genera*

Genus	Number of endemic species	Number of species found in Japan	Percentage (%)
<i>Lepadella</i>	11	14	78
<i>Lecane</i>	21	33	63
<i>Monostyla</i>	3	13	23
<i>Keratella</i>	5	22	23
<i>Brachionus</i>	4	23	17

The genus *Monostyla* has so close affinity with the genus *Lecane* that these two genera are hardly separated without the feature of toes, whether single or double. A few species are recorded to the *Monostyla* which have separate claws, while several *Lecanean* species have toes more or less fused together. In this respect, therefore, these two genera are often put in a single genus *Lecane*. However, those which have the toes of an intermediate type are fairly scanty in the number of species, compared with those which have typical toes. The continuity between the *Monostyla* and *Lecane* groups is not quite distinct. In addition, from the differences between the state of distribution of these two genera, the writer should like to separate them into two genera rather than to combine them into a single genus *Lecane*.

The composition of the rotatorian fauna of each district may be shown to some extent by the rate of the boreal and austral elements. The boreal rotifers are as follows: 15 % in the first district; about 9 % in both the second and the third; none in the eighth; 6—8 % in the rest. The austral species are: more than 10 % in the sixth,

seventh and eighth districts; 4—8 % in the third, fourth and fifth; very scanty in the first and second districts. The ratio of boreal to austral in each district will made intelligible by the state of faunal components; in other words, this index will tell us the boreal nature of the district (Table X).

TABLE X  
*Boreal indices of the I—IX districts*

District	I	II	III	IV	V	VI	VII	VIII	IX
Index ( $\frac{b}{a}$ )	13.0	4.0	3.0	0.65	0.9	0.3	3.00	0.20	0.00

The boreal components could not be observed in the western district, and in particular the boreal characters are considerably deficient in the district of the southern Pacific coast. The fourth district, which neighbours to the east of the above mentioned, is influenced by the warm current, and much austral characters are observed there. The number of localities in the Japan Sea coast district was small, but from the viewpoint of the boreal index, it will be better to divide into the north-eastern and western halves. Thence, the boreal index of the former half becomes the same as that of the third district, and that of the latter half is almost equal to that of the sixth. In the fifth district, the boreal components are nearly equal to the austral elements in the number of species. This district is worthy in this respect to be named the central district. The boreal elements increase more and more as the district moved from the third to the first through the second. In the course of the writer's observations on either the boreal or the austral rotifers, it became obvious that the limit of the boreal species is more distinct than the northern boundaries of austral species. Similar evidence was also observed on the affined or the same species in continental Asia, e. g., some species of the genera *Brachionus* and *Keratella*. *Brachionus calyciflorus* is distributed as far north as North Manchuria, while *Brachionus quadridentatus* does not enter upon any district in Korea south of Seoul. One of the reasons for such a fact might be ascribed to the scanty of collections in hibernal season. The restriction of distribution area of Brachionid members in Japan seems to be chiefly due to the scarcity of alkaline waters in contrast with the richness of those in continental Asia.

## SUMMARY

1. The present paper concerns the studies of the plankton rotifers of Japanese inland waters. For this purpose, the writer examined more than 1500 plankton samples from more than 200 localities which are distributed in almost all parts of Japan. They contained, though plankton samples, not a few number of creeping and sessile rotifers as temporal plankters.

2. With the addition of previous records, the number of Rotatorian species of Japan has become 186, with 28 varieties and forms, which belong to 4 orders, 13 families and 45 genera. They are enlisted in table III.

3. Japan is conveniently divided into 9 districts. The number of species recorded from each district is as follows: - 1) Hokkaidô, 68 species; 2) the north eastern district, 72 species; 3) the central mountainous district, 122 species; 4) the eastern Pacific coast district, 60 species; 5) the central district, 158 species; 6) the southern Pacific coast district (incl. Inland sea coast), 41 species; 7) the north eastern Japan Sea coast district, 31 species; 8) the western Japan Sea coast district, 25 species; 9) the western district, 38 species.

4. Some species noteworthy from various viewpoints are described. As the majority of plankton rotifers are of universal distribution, they are commonly found everywhere. So far as the rare and unusual species are concerned, the creeping rotifers have become the main subject of study. Among the euplanktic rotifers, only a few species are mentioned to be rare in Japan, namely, *Conochiloides coenobasis*, *Brachionus angularis* var. *chelonis*, and *Keratella javana*.

5. Those which are originated either in the boreal or in the austral region are noted. Most of the rotatorian species are cosmopolitan, and they may be found, with only a few exceptions, at any longitude, if the environmental conditions are suitable. Accordingly, when the problems toward the distribution are considered, either the latitude or altitude is of more interest than the longitude is. In Japan, the southern boundaries of boreal species could be clearly observed, while the northern boundaries of austral elements were comparatively vague.

6. So far as the widely distributed rotifers are concerned, there can be seen a tendency that the wider the distribution area, the larger the occurrence rate of pelagic species.

7. The samples obtained from brackish waters were not numerous. In the present study, *Brachionus plicatilis*, *Keratella cruciformis* var. *eichwaldi*, and *Pedalia fennica* were pointed out as the representative haline rotifers.

8. Some rotifers are well-known for their morphological variations.

Above all, the following species have very ample variability in morphological aspects; i.e., *Brachionus calyciflorus*, *Brachionus quadridentatus*, *Keratella quadrata*, *Keratella valga* and *Keratella cochlearis*. The last mentioned species are of most interest with respect to the difference of both the seasons and the localities.

9. The annual succession of plankton rotifers was observed at the southern basin of Lake Biwa-ko. The average changes of the important species examined during they from 1927 to 1937 were figured in the diagram.

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Nous prions le lecteur de nous excuser des nombreuses fautes typographiques émaillant ce travail.

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